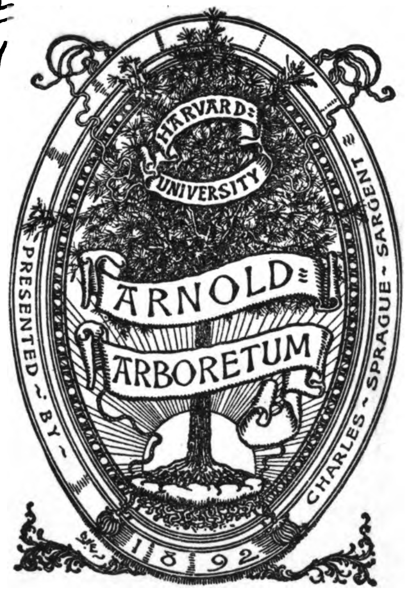
HARVARD
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PRESENTED BY CHARLES SPRAGUE SARGENT
1892

JOURNAL

OF THE

Elisha Mitchell Scientific Society

VOL. XXIII
1907

PUBLISHED BY THE UNIVERSITY
CHAPEL HILL, N. C.

31141

JOURNAL

OF THE

Elisha Mitchell Scientific Society

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VOL. XXIII.

1907.

VOL. XXIII MAY, 1907 NO. 1

JOURNAL

OF THE

Elisha Mitchell Scientific Society

ISSUED QUARTERLY

CHAPEL HILL, N. C., U. S. A.

TO BE ENTERED AT THE POSTOFFICE AS SECOND CLASS MATTER

Elisha Mitchell Scientific Society.

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Journal of the Elisha Mitchell Scientific Society—Quarterly. Price, $2.00 per year; single numbers 50 cents. Most numbers of former volumes can be supplied. Direct all correspondence to the Editors, at University of North Carolina, Chapel Hill, N. C.

JOURNAL

OF THE

ELISHA MITCHELL SCIENTIFIC SOCIETY

MAY, 1907

VOL. XXIII NO. 1

THE FOUNDATIONS OF GEOMETRY.

BY ARCHIBALD HENDERSON, PH.D.

The study of the historical development of mathematics, and in particular the study of geometry, leads one to the conclusion that the great roles in the drama of science have been played by two inter-related, yet widely differing, forces—intuition and logic. Huxley once laughingly said of Herbert Spencer that his idea of tragedy was a deduction killed by a fact. Some of the greatest parts in the drama of science have been played by intuition; but that drama becomes a tragedy when intuitional prevision is annihilated by the inexorable irony of fact. The most epoch-making discoveries find their origin in the fortunate conjunction of intuition and experience. And the whole history of science is the history of the struggle of man's intuition, fortified by experience, to read the inscrutable riddle of Nature.

I venture to assert that nowhere is this struggle more succinctly and definitively illustrated than in the story of man's effort to formulate the hypotheses which constitute the foun-

Printed May 13.

dations of geometry. For precise reasons, the names of Euclid and Newton stand above all other names in the *fasti* of mathematics; and the reasons are strikingly similar in the two cases. In writing of *The Wonderful Century*, the nineteenth, Alfred Russel Wallace says of all time before the seventeenth century: "Then, going backward, we can find nothing of the first rank except Euclid's wonderful system of geometry, perhaps the most remarkable mental product of the earliest civilizations." In modern times, Newton's colossal figure occupies the centre of the stage, looming large, as he himself explained, because he stood upon the shoulders of giants. Like Euclid, his claim to pre-eminence rests less upon the discovery of new principles than upon the immeasurably greater service of the universal formulation and grounding of mathematics. Newton brought all natural phenomena under the reign of universal law, Euclid reduced all geometrical knowledge to system.

"It is certain," says Philip Kelland, "that from its completeness, uniformity and faultlessness, from its arrangement and progressive character, and from the universal adoption of the completest and best line of argument, Euclid's *Elements* stand pre-eminently at the head of all human productions. In no science, in no department of knowledge, has anything appeared like this work: for upwards of 2,000 years it has commanded the admiration of mankind, and that period has suggested little toward its improvement." Indeed it is no cranky enthusiasm, but absolute conviction that prompts the mathematician to say that geometry is ultimately fundamental for the progress of science and thea dvancement of humanity. It is continually bringing to pass those epoch-making events in the history of science whereby what one day seems to be the purest science becomes the next a vitally important piece of applied science. Such events enable us to realize that pure science and utilitarian science are not differentiable, butat bottom and in essence one and the same thing. "I often find the conviction forced upon me," said the brilliant English

geometer H. J. S. Smith, "that the increase of mathematical knowledge is a necessary condition for the advancement of science, and, if so, a no less necessary condition for the improvement of mankind. I could not augur well for the enduring intellectual strength of any nation of men, whose education was not based on a solid foundation of mathematical learning, and whose scientific conceptions, or, in other words, whose notions of the world and of the things in it, were not bound and girt together with a strong framework of mathematical reasoning."

In that charming book, cast in the dialogue form and entitled *Euclid and his Modern Rivals*, by the Rev. Charles L. Dodgson, the brilliant "Lewis Carroll" of *Alice in Wonderland* fame, Euclid confesses with reluctance that some secret flaw lies at the root of the subject of parallel lines. Probabilities, not certainties, are all that he has in vindication of his belief. Here we lay our fingers on the rift in the lute; in this confession, we catch a glimpse of that *ignis fatuus* that mathematicians have pursued in vain for well-nigh two thousand years. Professor G. B. Halsted cites Sohncke* as saying that in mathematics there is nothing over which so much has been spoken, written, and striven, as over the theory of parallels, and all, so far (up to his time), without reaching a definite result and decision. It is impossible, says the great Poincaré, to imagine the vast effort wasted in this chimeric hope, this evanescent dream. Indeed, it was not until the nineteenth century that the truth began to dawn upon the minds of men; and almost simultaneously from the distant frontiers of Europe, at Kazan on the Volga and at Maros-Vasarhely in far Erdély, there came the startling generalizations that have tended to revolutionize our conceptions of geometry, and thrown doubts upon the very nature of the space in which we live.†

Encyclopœdie der Wissenchaften und Kunste; Von Ersch und Gruber, Leipzig, 1838, under "Parallel."

†Compare *The Value of Non-Euclidian Geometry,* by G. B. Halsted; Pop. Sci. Monthly, vol. 67, pp. 639-646. At the outset, I wish to acknow-

In order to make the matter clear to "the man in the street," it is necessary to speak, not so much as a mathematician as one who knows, let us say, no more of mathematics than is taught in the Freshman year in the college or university. We recall that Euclid uses three terms in laying the foundations for his geometry: *Definitions* ('όμοι), *Postulates* (αιτιήματα), and *Common Notions* (κοιναι εννοιαι). He defined his elements: point, line, etc.; he assumed that you can draw a straight line from one point to another; and he laid down as accepted such statements as "Things equal to the same thing are equal to each other," etc. For Euclid's *Common Notions* later geometers substituted the unfortunate term—unfortunate, as we shall subsequently see—*Axioms*. This word Axiom (Greek, αξιωμα) is used by Aristotle to mean "a truth so obvious as to be in no need of proof"—virtually in the modern sense of a "self-evident truth." Euclid used only five Postulates and thirteen Common Notions, none of which challenged doubt save the celebrated "parallel-postulate." Indeed, all were very simple except this fifth postulate,* which excited suspicion, not only on account of its cumbrous form, but because it is used only once—to prove the inverse of a proposition already demonstrated—the seventeenth. "It requires," says Staeckel, "a certain amount of courage to declare such a requirement, alongside the other simple axioms and postulates." The Swiss mathematician, J. H. Lambert,† averred that Proklos, Euclid's first commentator (410–485 A. D.) argued that the parallel-postulate was demonstrable, because it was the inverse of the seventeenth proposition. Euclid's twenty-seventh proposition: that straight lines

ledge my general indebtedness to the writings of Professor Halsted, to which I occasionally refer.

*Also given in various editions of Euclid as a Common Notion—eleventh, twelfth, or thirteenth.

†Lambert's *Theory of the Parallel Lines* was not published until 1786 twenty years after it was written and nine years after his death, by Bernouilli and Hindenberg in the *Magazin fur die reine und angewandte Mathematik.*

making with a transversal equal alternate angles are parallel, is easily demonstrated. But in order to prove its inverse: that parallels cut by a transversal make equal alternate angles, he is forced to resort to the following postulate axiomatically stated (Williamson's translation, Oxford, 1781):

11. *And if a straight line meeting two straight lines makes those angles which are inward and upon the same side of it less than two right angles, the two straight lines being produced indefinitely will meet each other on that side upon which the angles are less than two right angles (Fig. 1, Angle A + Angle B less than 180°).*

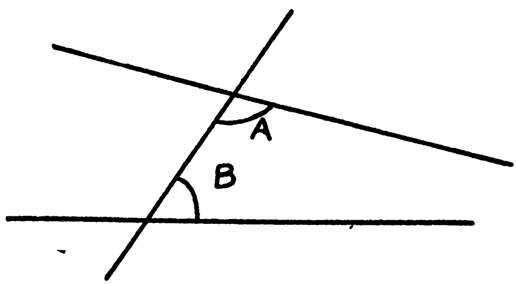


FIG 1.

The points to be observed in connection with this postulate are two in number. First, "no one had a doubt of the external reality and exact applicability of the postulate. The Euclidian geometry was supposed to be the only possible form of space-science, that is, the space analyzed in Euclid's axioms and postulates was supposed to be the only non-contradictory sort of space." Second, the postulate was neither so axiomatic nor so simple as the proposition it was used to prove; and hence the world of mathematicians concluded, with Proklos, that this postulate could be deduced as a theorem from the other assumptions and the twenty-eight preceding theorems. And so, for hundreds and hundreds of years, the

mathematical world exhausted itself in the effort to prove Euclid's celebrated parallel-postulate. Ptolemy, the great astronomer, wrote a treatise purporting to prove it; and Nasir Eddin (1201-1274), whose work on Euclid in Arabic was printed at Rome in 1594, sought to dispense with the problem of parallelism, by taking his stand upon another postulate: that two straight lines which cut a third straight line, the one at right angles, the other at some other angle, will converge on the side where the angle is acute, and diverge where it is obtuse. Other mathematicians, notably John Wallis whom I claim as an ancestor, sought to turn the flank of the difficulty by identifying the problem of parallels with the problem of similitude. In general, we may say that the problem was attacked from three sides.

First, there were those who sought to substitute a new definition of parallels for Euclid's, which reads (I, Def. 35):

> "*Parallel straight lines are such as are in the same plane, and which being produced ever so far both ways do not meet.*"

To cite a few classic definitions, Wolf, Boscovich, and T. Simpson use the following: "Straight lines are parallel which preserve the same distance from each other." But this is begging the question, asHalsted has remarked, since it assumes a *definition*, viz.: "Two straight lines are parallel when there are two points of the one on the same side of the other from which the perpendiculars to it are equal;" and at the same time assumes a *theorem:* "All perpendiculars from one of these lines to the other are equal." Those geometers who assume that parallel lines have the same direction are guilty of a *petitio principii*, in assuming (Varignon and Bezout) the *definition* that "parallel lines are those that make equal angles with a third line," and also in assuming the *theorem* that "Straight lines that make equal angles with one transversal make equal angles with all transversals."

The second method of attack, far more logical, was to pro-

pose a substitute for the parallel-postulate, such as "Two straight lines which intersect cannot *both* be parallel to the same straight line" (Ludlam), and "Any three points are collinear or concyclic" (Bolyai). And the celebrated Hilbert, in his *Vorlesung ueber Enklidische Geometric*, (winter semester, 1898-9) cites the following theorems:

1. The sum of the angles of a triangle is always equal to two right angles.
2. If two parallels are cut by a third straight line, then the opposite (corresponding) angles are equal.
3. Two straight lines, which are parallel to a third, are parallel to each other.
4. Through every point within an angle less than a straight angle, one can always draw straight lines which cut both sides (not perhaps their prolongations).
5. All points of a straight line have from a parallel the same distance.

His comment is, "Finally we remark, that it seems as if each of these five theorems could serve precisely as the *equivalent of the Parallel Axiom.*"

The third class of investigators consisted of those geometers who foundered upon the rock of the attempt to deduce Euclid's parallel-postulate from reasonings about the nature of the straight line and the plane angle, helped out by Enclid's other assumptions and his first twenty-eight theorems. Euclid took pains to prove things which were more axiomatic by far—for instance, that the sum of two sides of a triangle is greater than the third side—a thing which any ass knows. To give one illustration of the many so-called proofs, take the most plausible one, exposed by Charles L. Dodgson, in his *Curiosa Mathematica*, Part I. pp. 70-71, 3rd edition, 1890:

"Yet another process has been invented—quite fascinating in its brevity and its elegance—which, though involving the

same fallacy as the Direction-Theory, proves Euc. I, 32. without even mentioning the dangerous word 'Direction'.

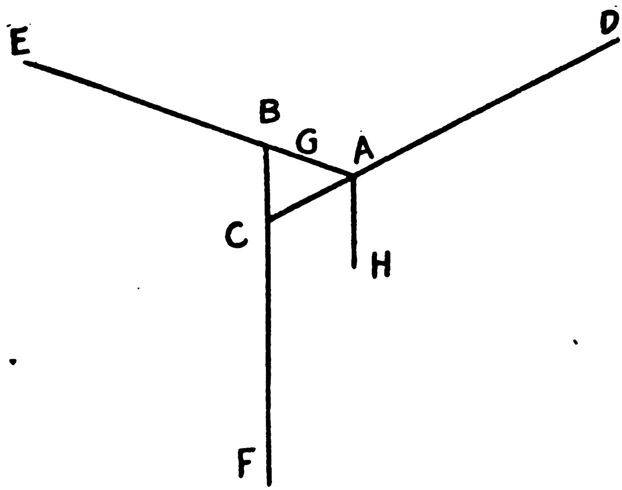


FIG. 2.

"We are told to take any triangle ABC; to produce CA to D; to make part of CD, viz., AD, revolve, about A, into the position ABE; then to make part of this line, viz., BE, revolve, about B, into the position BCF; and lastly to make part of this line, viz., CF, revolve, about C, till it lies along CD, of which it originally formed a part. We are then assured that it must have revolved through four right angles: from which it easily follows that the interior angles of the triangle are together equal to two right angles.

"The disproof of this fallacy is almost as brief and elegant as the fallacy itself. We first quote the general principle that we can not reasonably be told to make a line fulfil *two* conditions, either of which is enough by itself to fix its position: e. g., given three points X, Y, Z, we can not reasonably be told to draw a line from X which shall pass through Y *and* Z; we can make it pass through Y, but it must then take its chance of passing through Z; and *vice versa*.

"Now let us suppose that, while one part of AE, viz., BE, revolves into the position BF, another little bit of it, viz., AG, revolves, through an equal angle, into the position AH; and that, while CF revolves into the position of lying along CD, AH revolves—and here comes the fallacy.

"You must not say 'revolves through an equal angle, into the position of lying along AD,' for this would be to make AH *fulfil two conditions at once.*

"If you say that the one condition involves the other, you are virtually asserting that the lines CF, AH are equally inclined to CD—and this in *consequence* of AH having been so drawn that these same lines are equally inclined to AE.

"That is, you are asserting, 'A pair of lines which are equally inclined to a certain transversal, are so to any transversal.' [Deducible from Euc. I, 27, 28, 29]."

Thousands of mathematicians have tried in vain to prove something that only a genius could see was indemonstrable. The history of the evolution and exfoliation of that fertile idea is of very great interest to the mathematician of today, especially in view of the fact that beyond contradiction the most original researches of the last quarter of the nineteenth century pertain to the non-Euclidian geometry.

The most notable attempt to demonstrate Euclid's parallel-postulate that has been preserved to the world is embodied in a book entitled *Euclid Vindicated from every Blemish*, by a Jesuit priest named Hieronymus Saccheri (1667-1773).* He was in close association with the great Italian geometer Giovanni Ceva (through his brother Tommaso), whose name a celebrated theorem bears; and by purely geometrical methods in Euclidian style, he sought to apply the *reductio ad absurdum* method to the problem of the parallel-postulate. His method is essentially as follows: At the end-points of a sect AB erect two equal perpendiculars AC and BD on the

**Euclides ab omni naevo vindicatus; sive conatus geometricus quo stabiliuntur prima ipsa universae geometriae principia.* Auctore Hieronymo Saccherio Societatis Jesu, Mediolani.

same side of AB. Join C and D by a straight line; and it easily follows that the angle ACD is equal to the angle BDC. Now there are three possibilities: (1) The angle ACD is acute; (2) the angle ACD is obtuse; (3) the angle ACD is a right angle. He undertook to prove the absurdity of the first two possibilities so as to leave only the third possibility, viz., that the two angles ACD and BDC are each right angles. He pursued the lines of argument, following from the first two assumptions, at some length—for his book was more than a hundred pages long; but was doubtless amazed to discover that for quite a time he was unable to involve himself in any logical contradiction. In the event, certain of his conclusions were erroneous, and led him to believe that he had actually proved the parallel-postulate. What he really did do was to identify the assumption of the right angle with the parallel-postulate, thus showing the two to be mutually interchangeable postulates.

In 1766, Johann Heinrich Lambert wrote his theory of parallel lines, in which he starts from the notion of the sum of the angles of a triangle being equal to 180 degrees. If the sum is equal to 180 degrees, the triangle is a figure in a plane; if the sum is greater than 180 degrees, the triangle is on a sphere; if the sum is less than 180 degrees, the triangle is on the surface of an imaginary sphere (radius equal to the square root of minus one)—Lobatchevsky—Bolyai "imaginary geometry," so called because its trigonometric formulas are those of the spherical triangle if its sides are imaginary. As to the third hypothesis, Lambert naïvely said: "There is something attractive about this which easily suggests the wish that the third hypothesis might be true."*

France contributed little to the solution of the problem; recognition, however, should be given to Legendre, who stud-

*Compare *The Philosophical Foundations of Mathematics*, by Dr. Paul Carus; The Monist, vol. 13, pp. 273-294; 370-397; 493-522, to which I am indebted. I once had the pleasure of hearing Dr. Carus lecture on this subject before the Mathematical Club of the University of Chicago.

ied the problem all his life. By the aid of the principle of continuity, the so-called Theorem of Archimedes, he did prove two well known theorems:

1. In a triangle, the sum of the three angles can never be greater than two right angles.
2. If the sum of the three angles is equal to two right angles in one triangle, it is equal to two right angles in every triangle.

But Euclid's geometry can be built up without the continuity assumption; and only a short time ago, there was proved by Dehn, something that might have been inferred, viz., that Legendre's first theorem does not hold, i. e. not without the continuity assumption.*

In addition to Legendre, there was one other Frenchman, Joseph Lagrange, France's greatest mathematician in his day, who attempted to prove Euclid's parallel-postulate. Toward the end of his life, so the story runs, Lagrange composed a discourse on parallel lines. He began to read it in the Academy, but suddenly stopped, and, in confusion, stammered: "Il faut que j'y songe encore"—"I'll have to think about it a while longer." He stuck his manuscript in his pocket, sat down, and never recurred to the subject.

The first distinct epoch in the history of the non-Euclidian geometry begins with the time of the great German mathematician, Karl Friedrich Gauss. He is in no sense entitled to credit as a discoverer in this line, although for many years he occupied himself with the problem. The researches he claims to have made on the subject have not come down to us; but he was closely associated, according to abundant testimony, with Schweikart and Bolyai, two of the three independent discoverers of the non-Euclidian geometry. The publication in 1900 of the eighth volume of Gauss' *Collected Works* shows, from a letter to Bolyai, the elder, a Hungarian mathe-

*Compare *The Foundations of Geometry*, by David Hilbert; Translation by E. J. Townsend, Open Court Publishing Co., Chicago.

matician, that in 1779 Gauss was still hopelessly attempting to prove that Euclid's was the only non-self-contradictory system of geometry, and also the system of our space. Bolyai, the elder, submitted to Gauss, in 1804, a pseudo-proof of the parallel-postulate, but Gauss immediately detected the fallacy. When Bolyai, the elder, submitted a second pseudo-proof to Gauss, in 1808, he never replied. Bolyai's words, accompanying one of these pseudo-proofs, are pathetic in their earnestness and yearning: "Oft have I thought, gladly would I, as Jacob for Rachel, serve in order to know the parallels founded even if by another. Now just as I thought it out on Christmas night, while the Christians were celebrating the birth of the Saviour in the neighboring church, I wrote it down yesterday, and I send it to you enclosed herewith."

On November 23, 1823, Bolyai the son, called Janos, wrote a letter to his father, professor of mathematics at Maros-Vasarhely, in which he announces his discovery of the non-Euclidian geometry—a letter full of youthful fire and enthusiasm, from which I quote:

> "I intend to write, as soon as I have put it into order, and when possible to publish, a work on parallels. At this moment it is not yet finished, but the way which I have hit upon promises me with certainty the attainment of the goal, if it in general is attainable. It is not yet attained, but I have discovered such magnificent things that I myself am astounded at them.
>
> "It would be damage eternal if they were lost. When you see them, father, you yourself will acknowledge it. Now I cannot say more of them, only so much: *that from nothing I have created another wholly new world*. All that I have hitherto sent you compares to this only as a house of cards to a castle."*

His results were printed as an *Appendix* to his father's work, entitled *Tentamen Juventutem Studiosam in Elementa Matheseos Purae, Elementaris ac Sublimioris, Methodo Intuitiva, Evidentia—que huic Propria Introducendi.* The two dozen pages contributed by the younger Bolyai have been some-

**The Science Absolute of Space*, by John Bolyai, translated by G. B. Halsted; Introduction, pp. XXVII, XXVIII.

what exaggeratedly characterized as the most remarkable two dozen pages in the history of thought. When this work at last reached Gauss, he wrote to his pupil and friend, Gerling: "I hold this young geometer von Bolyai to be a genius of the first magnitude." Bolyai called his work, *The Science Absolute of Space, independent of the truth or falsity of Euclid's Axiom XI (which can never be decided* A PRIORI). And later, we read on the title page of the elder Bolyai's *Kurzer Grundriss*: "the question, *whether two straight lines, cut by a third, if the sum of the interior angles does not equal two right angles, intersect or not?* no one on the earth can answer without assuming an axiom (as Euclid the eleventh)." The work of Bolyai, the younger, which makes all preceding space only a special case, only a species under a genus, and requiring a descriptive adjective *Euclidian*, was rescued from oblivion, after thirty years, by Professor Richard Baltzer, of Dresden; and J. Hoüel, of Bordeaux, following in the steps of Baltzer, inserted extracts from Bolyai's book in his *Essai Critique sur les principes fondamentaux de la Geometrie elementaire.* Indeed, this scientist mastered the principal European languages in order to make known to his contemporaries the most celebrated mathematical works.

There is another name which deserves to become conspicuous in the history of non-Euclidian geometry; but not until 1900 were the facts in connection with his independent discovery accurately known. In a letter to the elder Bolyai, written October 31, 1851, Gerling, a scholar of Gauss and Professor of Astronomy at Marburg, wrote as follows: "We had here about this time (1819) a law professor Schweikart, who ...... had attained to similar ideas, since without help of the Euclidian axiom he developed in its beginnings a geometry which he called Astralgeometry. What he communicated to me thereon I sent to Gauss, who then informed me how much farther already had been attained on this way, and later also expressed himself about the acquisition, which is offered to the few expert judges in the Appendix to your

book." On the publication of volume 8 of Gauss's *Collected Works*, in 1900, light is at last thrown upon Schweikart's discovery. Here we find Gerling's actual letter to Gauss, written in 1819, in which he says, among other things: "Apropos of the parallel-theory, ... I learned last year that my colleague Schweikart .... had written on parallels........ He said that he was now about convinced that without some datum the Euclidian postulate could not be proved, also that it was not improbable to him that our geometry is only a chapter of a more general geometry."* Enclosed in this letter was a paper by Schweikart, dated Marburg, December, 1818. From this we learn:

> "There is a two-fold geometry—a geometry in the narrower sense—the Euclidian, and an astral science of magnitude.
>
> "The triangles of the latter have the peculiarity, that the sum of the three angles (of a triangle) is not equal to two right angles.
>
> '*This* presumed, it can be most rigorously proven:
>
> (a) That the sum of the three angles in the triangle is *less* than two right angles;
>
> (b) That this sum becomes ever smaller, the more content the angle encloses;
>
> (c) That the altitude of an isoscles right angled triangle indeed ever increases, the more one lengthens the side; that it, however, cannot surpass a certain line, which I call the *constant*."

It can be easily proved that if this constant is infinitely great, then, and then only, is the sum of the three angles of every triangle equal to two right angles.

That the doctrine made converts in high places is evidenced by Bessel's letter to Gauss, Feb. 10, 1829: "Through that which Lambert said, and what Schweikart disclosed orally, it

Gauss and the non-Euclidian Geometry, by G. B. Halsted; Science, N. S. Vol. XII, No. 309, pp. 842–846, Nov. 30, 1900.

has become clear to me that our geometry is incomplete, and should receive a correction, which is hypothetical, and if the sum of the three angles is equal to one hundred and eighty degrees, vanishes.

"That were the *true* geometry, the Euclidian, the *practical*, at least for figures on the earth."*

The third name most closely associated in the popular mind with the discovery of the non-Euclidian Geometry is that of Nicolai Ivanovich Lobatchevsky. This brilliant genius, afterwards dubbed by Hoüel the modern Euclid, was born in the year 1793 near Nijni Novgorod on the Volga. He studied under the great Bartels, was graduated with distinction, became professor of mathematics, and finally rector, of the University of Kazan. The manuscripts of certain of his works were lost, but fortunately there remains the world-famous *Geometrical Researches on the Theory of Parallels.*† While both Gauss and Lobatchevsky were students of Bartels, there is even less reason to believe that Gauss contributed to Lobatchevsky's, than that he assisted in Bolyai's, discovery of the non-Euclidian geometry. In his *New Elements of Geometry*, we find Lobatchevsky's clear enunciation:

> "The futility of the efforts which have been made since Euclid's time during the lapse of two thousand years awoke in me the suspicion that the ideas employed might not contain the truth sought to be demonstrated. When finally I had convinced myself of the correctness of my supposition I wrote a paper on it (assuming the infinity of the straight line).
>
> "It is easy to show that the straight lines making equal angles with a third never meet.
>
> "Euclid assumed inversely, that two straight lines unequally inclined to a third always meet.
>
> "To demonstrate this latter assumption, recourse has been had to many different procedures.

**The Philosophical Foundations of Mathematics*, by Paul Carus; The Monist, vol. 13. p. 280.

†Compare the English translation by G. B. Halsted, published by the University of Texas, Austin, 1891.

> **"All these demonstrations, some ingenious, are without exception false, defective in their foundations and without the necessary rigor of deduction."**

Lobatchevsky classifies all the co-planar lines through a given point A with reference to another co-planar line BC not passing through A, under two heads—cutting and non-cutting (Fig. 3). The transition from the non-cutting lines,

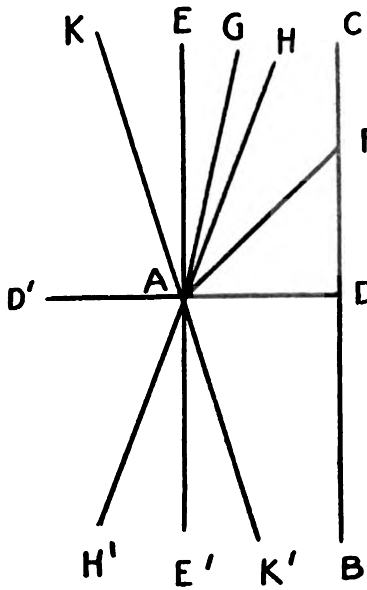


FIG 3.

such as EA and GA, to the cutting lines, such as FA, is marked by one line HA—the boundary line between the two classes; this he entitles the *parallel line*. From the assumptions, there arises the necessity of making a distinction of *sides in parallelism*, and hence there must be two parallels, so-called, one on each side. One logical consequence of this is that "if in any rectilineal triangle the sum of the three angles is equal to two right angles, this is also the case for every triangle"—one instance is the criterion for all.

As Poincaré, perhaps the world's greatest living mathematician, recently said, in his review of Hilbert's *Grundlagen der Geometrie*:

> "Lobachevski succeeded in building a logical edifice as coherent as the geometry of Euclid, but in which the famous postulate is assumed false, and in which the sum of the angles of a triangle is always less than two right angles. Riemann devised another logical system, equally free from contradiction, in which the sum is, on the other hand, always greater than two right angles. These two geometries, that of Lobachevski and that of Riemann, are what are called the *non-Euclidian Geometries*. The postulate of Euclid then cannot be demonstrated; and this impossibility is as absolutely certain as any mathematical truth whatsoever."*

Limits of space forbid more extended treatment of the work of Schweikart, of Bolyai, and of Lobatchevsky. By no means secondary in interest to the investigations of these men are the researches of Riemann upon the Elliptic Geometry; Cayley's projective theory of measurement, and the Absolute, leading through Klein to the non-Euclidian geometry; the hypotheses advanced by Clifford to explain the nature of the space in which we live; the popular expositions of Helmholtz; and Lie's great group-theoretic structure built upon the hypothesis of *Zahlenmannifaltigkeit*. Nor can I enter, at this place, into any discussion of the recent movement toward the treatment of geometry as a whole from the purely synthetic standpoint, inaugurated by Pasch, carried on by Peano, Pieri, and Veronese, and crowned by the masterly work of Hilbert. These modern investigators in what has been fittingly termed *abstract mathematics* have exhibited the potency of symbolism in removing from attention the

*Compare *The Value of Non-Euclidian Geometry*, by G. B. Halsted; Pop. Sci. Monthly, vol. 67, pp. 642-3.

concrete connotations of the ordinary terms of general and mathematical language. And yet, as Professor E. H. Moore has pertinently suggested, "the question arises whether the abstract mathematicians in making precise the metes and bounds of logic and the special deductive sciences are not losing sight of the evolutionary character of all life-processes, whether in the individual or in the race. Certainly the logicians do not consider their science as something now fixed. All science, logic and mathematics included, is a function of the epoch—all science, in its ideals as well as in its achievements.......... One has then the feeling that the carrying out in an absolute sense of the program of the abstract mathematicians will be found impossible. At the same time, one recognizes the importance attaching to the effort to do precisely this thing. The requirement of rigor tends toward essential simplicity of procedure, as Hilbert has insisted in his Paris address, and the remark applies to this question of mathematical logic and its abstract expression."*

Perhaps a not unnatural confusion may arise in the mind of the layman in regard to the ultimate meaning, the far-reaching significance of these discoveries. As Artemus Ward used to say, "Why this thusness?" Indeed so revolutionary have many of the new theories and discoveries appeared that their authors, in more than one instance, have hesitated long before giving them to the world. The pioneers in science sometimes dread, not inadvisedly, the possibility that their startling and epoch-making hypotheses and investigations may lead them to be dubbed sensationalists and fakirs. Compare, for example, the letter Gauss wrote to Bessel, Jan. 27, 1829:

> "I have also in my leisure hours frequently reflected upon another problem, now of nearly forty years standing. I refer to the foundations of geometry. I do not know whether I have ever mentioned to you my views on this matter. My meditations have also taken

**On the Foundations of Mathematics*, by E. H. Moore. Presidential address, Am. Math. Soc., Dec. 29, 1902. *Science*, March 13, 1903, pp.401-416.

> **more definite shape, and my conviction that we cannot thoroughly demonstrate geometry *a priori* is, if possible, more strongly confirmed than ever. But it will take a long time for me to bring myself to the point of working out and making public my *very extensive* investigations on this subject, and possibly this will not be done during my life, inasmuch as I stand in dread of the clamor of the Bœotians, which would be certain to arise if I should ever give *free* expression to my views."**

As that wayward Irishman, Bernard Shaw, has said, the prime and indispensible quality of the pioneer must be his willingness to make a fool of himself—at first! And it matters not in what sphere, whether art, literature or science, the great thing, as Henrik Ibsen says, is not to allow one's self to be frightened by the venerableness of the institution.

Now that the truth in regard to many of the mooted questions which pertain to the foundations of geometry has at last been daringly disclosed, the first question that naturally arises is: Has Euclid's fame suffered by the discovery? One might be led to think so if dependence were to be placed in Clifford's characterization of Lobatchevsky's celebrated monograph as "Euclid without the vicious assumption." Such a remark is not only misleading: it displays a fundamental misapprehension in regard to the Euclidian and non-Euclidian geometries. The real truth of the matter is that Euclid's genius today shines forth more resplendently than ever; the almost flawless perfection of his work is only thrown into clearer perspective and higher relief. From the purely philosophical, the metaphysical point of view, the discovery of the non-Euclidian geometry is of vast interest; for it gives rise to endless speculations in regard to the character of space—even of inter-stellar space. Are the three angles of a triangle equal to two right angles if the sides of the triangle are the distances from the earth to the remotest fixed star? In the realization that Euclidian geometry is only a chapter in a more general geometry, fitly entitled Pan-Geometry, and the consequent almost infinite extension of the domain of research consists the great value of the discovery to the mathemati-

cian. Most interesting comparisons between the different types of geometry flow from a study of certain surfaces. Since the sum of the three angles of a spherical triangle is greater than two right angles, it is evident that the characteristic geometry of the sphere is Riemannean; it has been known, since Lobatchevsky and Bolyai, that the characteristic geometry of the orisphere is Euclidian; since Beltrami, that of the Euclidian pseudo-sphere is Lobatchevskian.* Such generalizations as Barbarin's Theorem, for example, link together the various types of geometry in a most succinct and illuminative fashion, exhibiting with great clarity their fundamental distinctions and similarities. Text books in non-Euclidian geometry are now being written; Professor Halsted entitles a popular article *The Non-Euclidian Geometry Inevitable.* The first step toward the popularization of non-Euclidian geometry is the clear enunciation, at the proper place in our ordinary text-books of geometry, of the principle on which the Euclidian geometry rests: that from the standpoint of pure logic the parallel-postulate is a mere choice between alternatives. "In all the books put into the hands of students," as M. Barbarin has said, "the hypothetical and wholly factitious character of the Euclidian postulate (should) be put well into relief."†

The second great gain from the discovery of the non-Euclidian geometry is the possibility of the formulation of the principles of the general geometry. It is most instructive and stimulating to the mathematical student to see the theories of Euclidian geometry emerge as special cases of the more general and comprehensive theories of Pan-Geometry. The

*If we consider the tubes or surfaces equidistant from a straight line, and make that distance infinite, we have the orispheres; the pseudo-spheres are surfaces of revolution which have for meridians a tractrix or line of equal tangents. A pseudo-sphere finds its approximate counterpart in nature in a morning-glory whose stem is infinitely prolonged; for a figure, cf. *Elements of Trigonometry*, by Phillips and Strong, p. 126.

†*On the Utility of Studying Non-Euclidian Geometry*, by P. Barbarin; Le Mathematiche, May, 1901.

general geometry contains many propositions common to all the systems, which should be enumerated in the same terms in each of these. Sometimes a modification in the form of statement, veiling the special property of the figure in the particular type of space, would result from a generalization of the theorems for the general geometry, in which case such special properties should be clearly indicated. Thus, to state an illustration cited by M. Barbarin,* that of the convex quadrilateral inscribed in a circle, in Euclidian geometry, *the sum of two opposite angles is constant and equal to two right angles*; in non-Euclidian geometry, *this sum is variable.* Notwithstanding this, the two forms may be reconciled, since in both cases *the sum of two opposite angles equals that of the other two*, and this is sufficient for a convex quadrilateral to be inscriptible. Such generalizations often lead to a complete redistribution of values, and so clarify the processes of Euclidian geometry in the most distinctive way. Professor E. Study has said:

> "The conception of geometry as an experimental science is only one among many possible, and the standpoint of the empiric is as regards geometry by no means the richest in outlook. For he will not, in his one-sidedness, justly appreciate the fact that in manifold, and often surprising ways the mathematical sciences are intertwined with one another, that in truth they form an indivisible whole.
>
> "Although it is possible and indeed highly desirable that each separate part or theory be developed independently from the others and with the instrumentalities peculiar to it, yet whoever should disregard the manifold interdependence of the different parts, would deprive himself of one of the most powerful instruments of research.
>
> "This truth, really self-evident yet often not taken to heart, applied to Euclidian and non-Euclidian geometry, leads to the somewhat paradoxical result that, among conditions to a more profound understanding of even elementary parts of the Euclidian geometry, the knowledge of the non-Euclidian geometry cannot be dispensed with."†

**On the Utility of Studying non-Euclidian Geometry*, l. c.

†*Ueber Nicht-Euklidische und Linien-Geometrie*, Greifswald, 1900.

Lastly, the discovery of the non-Euclidian geometry virtually fixes upon the Euclídian geometry its practical and empirical character. "In connecting a geometry with experience," to cite the view of the most confirmed of non-Euclidians, "there is involved a process which we find in the theoretical handling of any empirical data, and which therefore should be familiarly intelligible to any scientist. The results of any observations hold good, are valid, always only within definite limits of exactitude and under particular conditions. When we set up the axioms, we put in place of these results statements of absolute precision and generality. In this idealization of the empirical data our addition is at first only restricted in its arbitrariness in so much as it must seem to approximate, must apparently fit, the supposed facts of experience, and, on the other hand, must introduce no logical contradiction. Thus to-day the ordinary triply-extended space of our experience may be purely Bolyaian, or purely Euclidian, or purely Cliffordian, or purely Riemannian."* To put it extravagantly, the non-Euclidian geometer, like a croupier, cries out to his audience: "Here are three assumptions in regard to the angle sum of a triangle; from not one of the three do any logical contradictions follow; which one will you take? *Messieurs, faites vos jeux!*" The result is, not that the mathematical world singles out one to the exclusion of the others—but studies all three, their inter-actions, inter-relations, and mutual dependencies. And yet if the "man in the street" impatiently cries out: "I am not interested in what may be the possible nature of space in the vicinity of Mars, or even the possible character of geometrical figures on the planet Jupiter, or in the tortuous reasonings of a mathematical Alice in Wonderland. Tell me, what is the character of the space I occupy, the nature of the physical world in which I live and move and have my being?" And the answer of mathematicians throughout the world, with certain distinguished exceptions,

***The Appreciation of non-Euclidian Geometry*, by G. B. Halsted; *Science*, March 22, 1901, pp. 462-465.

would doubtless be: "Although it can never be mathematically demonstrated, our space I believe to be Euclidian space because of the testimony of experience." The three angles of a triangle can never be mathematically demonstrated to be equal to two right angles; nor can experience ever give the absolutely exact metric results desiderated. And yet, this thing amounts to what we crudely call "moral certainty", viz. that the "practical geometry", as Bessel rightly called it, within reasonable limits of error—for which we must always allow in this imperfect world—, and for limited portions of space, is Euclidian. So, after all, it seems that we are forced to the conclusion that the axioms of geometry, although they are, abstractly speaking, assumptions, are, practically speaking, deductions from experience. Only as suppliants at the feet of Nature herself can we ever hope to penetrate to the heart of her mystery.

A NEW COLOR TEST FOR THE LIGNOCELLULOSES.

ALVIN S. WHEELER.

The lignocelluloses give a number of color reactions, the most valuable being the reaction with phloroglucinol in hydrochloric acid solution. The rich reddish violet color is very pronounced. The salts of anilin give a golden yellow but the color is not sufficiently dark to allow them to compete with phloroglucinol. However, I have observed that the salts of the nitranilines produce a color which is very striking, a rich blood red color. As phloroglucinol solutions are said to deteriorate with age, I have kept for one year exposed to full daylight a hydrochloric acid solution of phloroglucinol and also one of paranitraniline. The phenol solution became brown, showing some decomposition and on applying it to pine sawdust the violet color was not fully developed instantly but in a few minutes became as dark as that made by a fresh solution. The nitraniline solution was perfectly stable and gave its reaction as quickly as a fresh solution. So far as a year's time is concerned the new reagent has no real advantage over the old.

The red color is produced by the salts of the ortho, meta and paranitranilines but the meta compounds are much inferior, the color being pale in comparison. The ortho and para compounds give the same deep color. Paranitraniline is to be preferred since it is more readily obtained. Different salts of this amine such as sulphate, nitrate, hydrobromide and hydrochloride were tested but no difference was noted. The hydrochloride was adopted for use. This salt, dissolved in pure water, only gives a yellow color, but on stand-

ing for some hours the red color develops. Since the best results are obtained when free acid is present, various strengths of hydrochloric acid were tried from one-half to a twelve per cent. solution but no important difference could be observed. It is convenient to use an acid of specific gravity 1.06. A study of various concentrations of the paranitraniline in acid solution revealed no differences of consequence. It was observed that in all cases hot solutions produced much quicker results than cold ones. In fact hot solutions seemed to give the full depth of color instantaneously.

The reagent was applied to a wide variety of woods, to jute, to oat straw and to many samples of paper. A No. 1 book paper showed numerous small red fibres, indicating adulteration with mechanical wood or else incomplete conversion of the lignocellulose. A yellow paper containing five per cent. of mechanical wood gave a deeper color, likewise a salmon pink paper. A very deep blue paper made of sulphite cellulose showed scattering red fibres which were easily seen. A sample of white paper made from bleached sulphite gave no trace of color.

A striking lecture experiment is carried out by projecting a quantity of the hot solution against a large sheet of paper made of mechanical wood, such as newspaper stock.

In conclusion, the reagent is made by dissolving two grams of paranitraniline in one hundred cubic centimeters of hydrochloric acid, either of specific gravity 1.06 or a 4N solution. When used hot, a blood red color is instantaneously obtained with lignocelluloses.

University of North Carolina,
February 21, 1907.

NOTES ON THE GEOLOGY OF CORE BANK, N. C.

BY COLLIER COBB.

The storm of October 17th, 1906, cut three inlets across Core Bank, just below Cedar Island Inlet (closed since 1805) and near the site of Old Drum Inlet (closed in 1822), and revealed the fact that the beach sands and dunes (Columbia) rest upon a clay foundation (Neocene), which in its turn is underlaid by Tertiary shell-rock, exactly similar to the shell rock occurring at various points in Currituck Sound and already noted in this Journal.* Among the forms observed here were *Turritella*, *Lunatia*, *Glycymeris*, *Tornatellaea*, *Nucula*, *Lucina*, *Corbula*, *Protocardia*, *Modiolus*, *Arca*, *Ostrea*. These were in most cases packed together in the shell-rock, and a few sharks' teeth were included. The upper portion of this rock was made up almost entirely of the shells of *Tellina*. After the storm the entire bank in the region of the new-formed inlets was black with magnetic sands, heavily ripped, their thicknes being in some cases as much as three inches.

Numerous water-worn shells of *Cardium*, *Anomia*, *Exogyra*, *Serpula*, *Gryphaea*, of species identical with those found by the writer on Currituck Banks, were washed up by the storm, as were also the bones of fishes, all these being Cretaceous fossils. Many coral fragments were also found. The Captain of the Core Bank Life Saving Station, Willis, sailed through one of the inlets and found six feet of water in its shallowest part. On December 16th, 1906, I walked across all three of the inlets at low water in company with Captain Wm. T. Willis of the Core Bank Life Saving Station,

*Vol. xxii, No. 1, 1906, pp. 17-19.

and Mr. R. C. Holton of Atlantic, the washing up of sand from the sea and the southward movement of the dunes having nearly filled them.

The Tertiary shell-rock was encountered in Core Sound between Core Bank and Cedar Island, and between Core Bank and the mainland. There is thus no longer any question as to the origin of Core Bank or of Currituck Bank, for they are both essentially parts of the mainland. Currituck Sound was formerly a river that flowed into the Albemarle or Caroline River before the present Albemarle Sound was formed by the drowning of that valley; and Core Sound was for the greater part of its length a southern tributary of the large river made up of the Pamlico and the Neuse, and passing to seaward through the present Ocracoke Inlet. The Albemarle River passed through the present fresh ponds just south of the Kill Devil Hills, and the margin of the continent was some three score miles eastward of its present position.

Then came the subsidence which drowned out the lower river valleys producing the estuaries and sounds already mentioned, and this subsidence may still be in progress in the region to the north of Cape Hatteras.

Since that subsidence, however, there has been an uplift of the land from Cape Hatteras southward, which, in all probability is still going on. As the dunes advance towards the sound side they depress by their weight the swamp muck in which the trees of that side grow, and these are left exposed on the seaward side when the dunes have passed. This compression of the muck, which is common from Hatteras Island northward, may easily be mistaken for subsidence of the land.

But on the land opposite Core Bank, successive strata of muck, filled with well-rounded wind-blown sands rise twenty feet above Core Sound at Atlantic. Kitchen middens, too, mark this line of elevated shore, the heaps being composed mainly of oyster shells with an occasional bit of broken

Indian pottery, and an occasional stone cleaver. Similar evidences of recent elevation have been observed by the writer at various points from Cape Hatteras to Cape Sable.

NOTE—This paper was presented, with lantern illustrations, before Section E, of the American Association for the Advancement of Science, New York, December 31st, 1906, and an abstract appears in *Science* **N. S. vol. xxv, p. 297, Feb. 22, 1907.**

NOTE ON ELECTRICAL AGEING OF FLOUR.

J. W. GORE.

The Alsop Process of Ageing flour was described in the Electrical World of December 8th, 1906, which is now in use in many mills in the United States and also in foreign countries.

The apparatus consists of a 500 volt Shunt Wound dynamo, with an induction coil in series with it, and an air pump.

The circuit is automatically broken at each stroke of the pump; the break is between two copper electrodes, and the resulting arc is drawn out until broken.

The air through which this flaming Electrical discharge passes is forced by the air pump through the flour as it comes from the mill.

A 1½ kw dynamo is sufficient for a mill of some 30 to 40 barrels daily output.

It has been the practice of millers and warehouse men for a long time to age fresh flour by storage, thus fitting it better for bread and yielding a higher grade product. By Alsop's process these beneficial results are obtained in a few moments.

The conclusion is that the active elements in the atmosphere which improve the bread making qualities of the flour when stored, are plentifully produced by the flaming discharge of Electricity between Copper Electrodes.

INDUSTRIAL AND SCIENTIFIC ASPECTS OF THE PINE AND ITS PRODUCTS.*

BY CHAS. H. HERTY, PH.D.

Consideration of the annual production of volatile oils shows at once the great preponderance of spirits of turpentine over all others combined. Each quart of spirits of turpentine represents approximately one year's output of this product from one tree. At least nine-tenths of the world's supply of this substance comes from our Southern States, for the production of which not less than one hundred and twenty millions of trees are annually subjected to turpentining. Two millions of acres of virgin timber are annually brought into operation to supply the place of exhausted timber. Millions of pines which have never been turpentined are felled each year by the mills in Mississippi, Louisiana and Texas. Every winter the entire turpentine producing section is swept by ground fires which destroy most of the seedlings, and thus make impossible reproduction on any large scale. The annual revenue from the naval stores industry can be conservately estimated under present prices at not less than forty millions of dollars. Surely such a situation justifies and demands systematic experimental work in the hope of conserving this valuable native resource.

EFFECT OF TURPENTINING ON LUMBER.

The pine has a two-fold commercial value, first, as timber, second, as a producer of the oleo-resin, "crude turpentine."

*Reprinted from *The Chemical Engineer*, March, 1907.

For many years it was believed that timber which had been turpentined, commonly called "bled timber," was inferior to "unbled" for construction purposes. A thorough investigation of this question in 1893 by the Division of Forestry of the U. S. Department of Agriculture showed the fallacy of this belief, and now no distinction is made. Indeed in France timber from trees which have been turpentined is preferred for all purposes where strength and elasticity are demanded.

CRUDE TURPENTINE.

Previous to the last twelve years no systematic experiments had been carried out in this country on the production of crude turpentine. The records of the U. S. Patent Office as far back as 1869 show various inventions designed as substitutes for the "box," this being a deep hole cut in the base of the tree, having a capacity of about one quart and serving to collect the crude turpentine which flows from the scarified trunk above. None of these devices however gained permanent favor among turpentine operators. In 1894 W. W. Ashe, of the N. C. Geological Survey, began a comparative study of crude turpentine collected by the "box" system, uniformly practiced in this country, and by the "cup" or Hugues system, practiced in France. These experiments were planned with care, and although carried out on a small scale gave interesting results. They were discontinued after one year.

In the hope of accomplishing something toward the conservation of the pine forests of Georgia I began during the summer of 1901 field experiments on the production of crude turpentine by the pine. With an apparatus somewhat similar to that used in France, but essentially modified to suit our system of scarification or "chipping," various studies, both qualitative and quantitative, were made in the pine forests of the southern part of the State. Many of the specimens collected were afterwards examined in the chemical laboratory. The striking character of the results obtained aroused the interest of the U. S. Bureau of Forestry, and during the fol-

lowing winter I was led to accept a commission in the Bureau for the purpose of carrying out on a commercial scale the experiments already begun.

As introductory to the discussion of that work let me explain briefly the operations commonly in practice in the turpentine woods. During the winter the "boxes" are cut in the trees. In early spring the weekly scarification or "chipping" begins. It is necessary to renew this wound each week, as the flow of crude turpentine practically ceases after seven days. Chipping extends each year about eighteen inches up the tree, the depth of the cut being about one inch and the width, on an average tree, fourteen inches. When the boxes fill, usually every four or five weeks, the crude turpentine is removed to buckets, then to barrels and hauled to the still. During the year some of the product remains sticking to the exposed "face" of the tree. This is collected in the fall and distilled, although it has a much smaller percentage of spirits of turpentine than the "dip" from the boxes. Lastly a space around each tree is cleared of all combustible material as a protection against the annual ground fires.

The basis of my work was the conviction that the pine is not so much a store-house but rather a factory for the production of crude turpentine, and that timber which is not boxed should produce more than timber whose vitality is diminished by the cutting of the box. Comparative experiments were carried out in 1903 at Ocilla, Ga., on thirty thousand trees. In these experiments both the "box" and the "cup and gutter" systems were used under conditions as nearly identical as possible. The results showed an even greater difference in favor of the unboxed timber than was expected, while the qualitative results previously obtained by Ashe were confirmed. The immediate commercial introduction of the cup and gutter system was assured by the financial gain from the increased output, the improved quality of the rosin and the protection given to the trees against wind and fire.

For the production of crude turpentine it is necessary to

wound the tree. If the tree is girdled it dies. What then is the limit of wounding to which it is necessary to subject the tree in order to get the most profitable yield, and beyond which it is unsafe to go? It had been proved at Ocilla that the box was an unnecessary wound and that by its elimination the yield could be increased. The next step then was to make comparative tests bearing upon the extent of the wound given in "chipping." For the past two years such experiments have been conducted in Florida by the U. S. Forest Service, and by the courtesy of the Service I am enabled to tell you that results already obtained show that shallow chipping produces as much or eventually more crude turpentine than the customary deep chipping, while at least one year in three can be gained in the usual rate of ascent of the tree without diminishing the output. Still other experiments yielding most valuable results are in progress, all bearing upon more conservative wounding of the tree. None of these experiments are extreme, but all are rational modifications of present practices which will carry conviction when the details are published.

Of an entirely different character from the experiments just mentioned, but of great scientific and practical value, are the recent studies of Prof. A. Tschirch, of Switzerland, on resin secretion. By the use of the microscope and suitable stains he has proven that the seat of resin production is in a mucilaginous layer lining the inner walls of the resin ducts. In a later study, carried out upon a large number of trees, he has further demonstrated that while there are a limited number of "primary" resin ducts present in the untapped pine, by far the greater flow of resin proceeds from secondary ducts formed in the outer sap wood after the wounding of the tree. The resin from the "primary" ducts is a physiological product, that from the "secondary" a true pathological product.

While many chemical studies have been made of the products obtained by distillation of crude turpentine, only one detailed investigation is on record regarding the nature of the

oleo-resin secreted in the Longleaf pine. Tschirch and Koritzschoner have shown that this oleo-resin consists of

Palabienic Acid—$C_{13}H_{20}O_2$	5	per	cent.
Palabietic Acid—C[illegible]$H_{30}O_2$—	6	"	"
α and β—Palabietiolic Acid—$C_{16}H_{24}O_2$—	56	"	"
Spirits of Turpentine	20	"	"
Paloresene	10	"	"
Impurities, Bitter Principle and Water	3	"	"

No study has been published of the oleo-resin from Pinus Heterophylla, or Cuban pine, which occurs so frequently in the Florida forests and from which therefore so large a proportion of the present supply of spirits of turpentine and rosin is prepared. Such an investigation has been begun in the laboratory of the University of North Carolina.

Many interesting new lines of investigation in this field suggest themselves if the chemist instead of waiting for specimens to reach the laboratory will study and note the changes at the tree. When the oleo-resin first appears it is a perfectly clear liquid. In the case of some pines it remains thus for weeks and then slow crystallization of the dissolved acids begins, with others the crystallization begins within a minute after the drop appears. Evidence already in hand points to the probability that the clear liquid issuing from the resin ducts is a supersaturated solution. To what is this condition of supersaturation to be ascribed? Again, the flow of resin is relatively rapid during the first forty-eight hours after wounding, then quickly diminishes and practically ceases after seven days. Is this cessation to be explained by the plant physiologist or by the chemist? Has the inner lining of the resin duct lost its power of production, or has the duct been closed by oxidation, or crystallization of the oleo-resin which it exudes? If chemical, can it be prevented by some simple means? A practical solution of this problem would be a great blessing to the turpentine operator in these days of scarcity of labor and would do more than anything

else for the preservation of our pine forests. Still again—what is the chemistry of "scrape" formation? Why the variation in the amount of scrape formed in pines of different species and even among those of the same species? These are a few of the many problems in this untouched field awaiting the skill and patience of the investigator.

DISTILLATION.

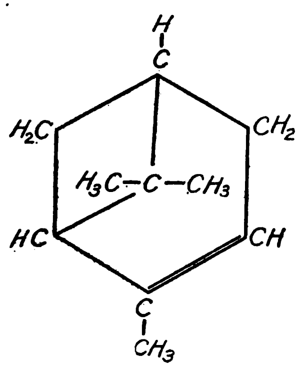
Crude turpentine is of very little commercial use. It must be separated by distillation into its constituents, spirits of turpentine and rosin. In this country distillation is carried out in large copper stills heated by direct fire. During distillation a current of warm water is let into the still. The steam produced by the water added during distillation materially lowers the temperature and lessons the time necessary for the complete removal of the spirits of turpentine. An interesting study of this subject from a physico-chemical standpoint has been made by Prof. Vezes, of Bordeaux. By distilling at this lower temperature the possibility of destructive distillation of the rosin is avoided. The vaporized spirits of turpentine and the steam are condensed in a water jacketed copper coil and collected in a suitable vessel where separation takes place owing to the difference in specific gravities and the mutual insolubility of the two liquids. On completion of the distillation the cap of the still is removed and the excess of water boiled off to prevent opaqueness in the rosin. The molten rosin is then run through an opening near the bottom of the still into strainers lined with cotton batting through which it filters into a vat. After partial cooling the rosin is dipped into barrels where it slowly solidifies.

During the summer of 1903 I had opportunity to study the systems of distillation practiced in France. Three types were found, first distillation by free flame and addition of water, as in this country, second by steam alone in steam jacketed stills, and third by a system of "mixed injection," i. e. free

flame and addition of water together with steam injection. The cost of a plant for distillation by steam alone is far greater than that of the simple plants in this country. After careful study of these systems I am convinced that if a skillfull "stiller" is in charge, as good results are obtained here as with the best of the French steam stills, but the personal equation, which plays no role in the steam still, is of prime importance with us. Perhaps the best of these for our conditions would be that of mixed injection, for the extra cost of installation and operation is not great and the personal element of the "stiller" is entirely eliminated.

SPIRITS OF TURPENTINE.

The chief constituent of spirits of turpentine is pinene, $C_{10}H_{16}$. Many battles have been waged over the structural formula of this compound. At first it was classified among the open chain hydrocarbons but later was shown to be a ring compound. Of the many formulas proposed that of Wagner is most in accord with the reactions of the substance.



Some of the work upon American spirits of turpentine has been in vain, because investigators failed to take into account the facts that in our turpentine orchards more than one species of pine is turpentined and that the crude turpentine from each is indiscriminately mixed when collected. Recognizing these

facts J. H. Long in 1893 secured specimens from identified individual trees, distilled the volatile oils from each and concluded that while American turpentine rotates the plane of polarized light to the right the variations in the amount of rotation in different specimens is due to admixture of the lævo-rotatory oil from Cuban pine with the dextro-rotatory oil from theLong leaf pine, and as the latter tree generally predominates the resultant oils are more or less dextro-rotatory. New light has been thrown upon this subject by an investigation carried on during the past year in the chemical laboratory of the University of North Carolina in collaboration with the U. S. Forest Service, by which the results of this study are to be published shortly. Through the courtesy of the Service I am enabled to refer to some of the results of special interest in this connection. During the past season, at regular intervals of four weeks, the crude turpentine has been collected separately from seven Longleaf and seven Cuban pines. A study of the oils distilled from these specimens has shown a marked variation in the rotation of polarized light. The variation exhibits itself not only in the oils from the two species of pines, but even among those from the same species. The Longleaf pines generally yielded dextro-rotatory oils. One, however, yielded a lævo-rotatory oil, while another scarcely affected the plane of polarization. The Cuban pines gave generally lævo-rotatory oils but through wide variations, one of them effecting only a very slight rotation. In the case of each tree, however, the rotation of its oil was found to be practically constant throughout the season.

The rapid rise in the price of spirits of turpentine during the past few years has led to frequent adulteration and the offering for sale of many substitutes. The producer, tempted by the great difference in price of spirits of turpentine and kerosene, has frequently mixed the two. The remedy was peculiar. Seeking to advance the price by producing less spirits of turpentine, the operators soon found that their successful effort to curtail had been fully off-set by the addition,

at many stills, of kerosene sufficient to keep the output at its former figures. The most prominent producers then led the fight for "pure spirits" laws and in the largest producing States effective legislation on this subject has been enacted. Similar laws have recently been passed in New York State.

Mineral oil constitutes the chief adulterant of spirits of turpentine. While such an addition may not materially lower the solvent power, it diminishes the oxygen carrying power directly in proportion to the amount present, since American petroleum is composed almost wholly of saturated hydrocarbons. So skillful has become the art of adulterating with petroleum products that detection by the ordinary physical tests can be evaded if the adulterant is not present in too great quantity. But by polymerization of the terpenes with concentrated sulphuric acid, Herzfeld's method, adulterations even as low as one to two per cent. can be detected with certainty. Especially is this true if after successive polymerizations the oils, distilled with steam, be examined with the refractometer, as recommended by McCandless.

No discussion of spirits of turpentine would be complete without embracing that form now legally designated as "wood spirits of turpentine." It is no new thing that a volatile oil, various heavy oils and charcoal can be obtained by destructive distillation of "fat lightwood." More than forty years ago extensive plants for such distillation were in operation in North Carolina. But the low price of spirits of turpentine made these financial ventures unsuccessful. A few plants continued operations on a small scale, but the matter dropped out of public notice for a long while. With the recent rise in price the subject was again agitated. By the aid of clever promotion, by the exhibition of actual results obtained, but from raw material above average richness, by frequent reference to latter-day success in saving and utilizing by-products and finally by that sweet vision of pestiferous stumps removed from the cotton rows, great enthusiasm was raised, and at one time unlimited capital was available for destructive dis-

tillation plants, provincially called "stump factories." Many were built, but it was soon found that the paint and varnish people did not want the product, as the quality was irregular and the odor bad. Then, too, the by-products so carefully saved found no market. Finally through faulty construction or careless management many of the plants burned. Consequently destructive distillation lost favor and plants were erected for the extraction from lightwood by steam of spirits of turpentine alone. This method gives an oil of good quality, and with increased experience a product is now manufactured which is practically the same as "gum spirits." But the yield from average raw material is rather low and if it be sought to increase the yield by elevation of temperature the quality is inferior.

I think I have stated the case fairly. We all hope that this industry will eventually be placed upon a good solid basis. Let me emphasize three points in connection with this subject:—

First.—Fewer promoters and more chemists would improve the situation.

Second.—Investors must not expect to realize the enormous profits claimed by some of the over-enthusiastic, but the business is capable of yielding fair dividends if the plants are properly located and carefully managed.

Third.—In spite of the preference now shown for steam extraction, the future of this industry lies in destructive distillation, but not as at present practiced. The difficulty of securing profitably a permanent supply of raw material will lead to the establishment of numbers of cheap stills. Such stills require no expert labor and can be easily moved from time to time to fresh portions of the territory for raw material. The crude product from these small stills will be shipped to central refineries where suitable apparatus will be found operated under the direction of chemists.

ROSIN.

What is rosin and of what chemical compounds is it

composed? This question has interested chemists for many years. The literature of the subject is very extensive and the views held at various times were and even now are widely different. By Maly and Flückiger rosin was considered the anhydride of abietic acid. Henriques contended for the presence of lactonic acids, Benedict for free acids and ethereal salts, Fahrion for sylvic acid, while Tschirch has recently separated from American rosin three isomeric acids α, β and γ abietic acids, and considers that all other workers in this field have been dealing with impure products. The controversy on this subject between Tschirch and Fahrion is not yet ended. Tschirch can not decide between $C_{19}H_{28}O_2$ and $C_{20}H_{30}O_2$ as the correct formula for abietic acid. Nor has it been determined with any certainty whether the oxygen atoms of this acid are present in the form of hydroxyl or carboxyl groups. It is possible that some of these differences may be due to the fact that many of the specimens used for investigations are so called "American Rosins," without taking into account the fact that much of this rosin is derived from at least two different species of pines, Pinus Palustris and Pinus Heterophylla.

Rosin varies in color from a pale yellow to a very deep red, the price of the rosin decreasing with increasing color. In France the better grades of rosin are placed in shallow trays and exposed for three or four months to the bleaching action of sunlight. Almost colorless grades are thereby obtained. This practice is carried on by one firm in this country. But sun-bleaching is not effective with the darker rosins. The great difference in price between the low and high grades has led to many efforts to devise chemical methods for bleaching rosin. A number of patents have been issued on the subject, but so far as I know none of these have proved commercially profitable. Here is a live problem for the chemist, the correct solution of which is certain to bring rich returns.

For many years the commercial demand for rosin was very

limited. Indeed at one time the price dropped so low that it was frequently the custom in North Carolina to distill the oil from the crude turpentine and turn the rosin into the creeks and swamps. In these latter days of higher prices the rosin from these dumping grounds has been dug up, melted, strained and shipped to market. The cause of this increase in price is not difficult to discover. It is the manufacture of rosin oil. Of the total amount of rosin produced about 10 per cent. is used for sizing, varnishes and other minor matters, 35 per cent., approximately, for soap making, while not less than 55 per cent. is subjected to destructive distillation whereby rosin spirits, various rosin oils, brewers pitch, etc., are obtained. As a substitute for or adulterant in linseed oil, as lubricants, in printer's ink and in many other ways rosin oils are finding wider and wider application. This industry thrives chiefly in Germany, to quite a large extent in England and Scotland, and a much more limited extent in France, where a high tariff prevents the importation of American rosin. In this country there are about three rosin oil distilleries, operated somewhat in the same manner as the European plants. Why should not this industry thrive in our Southern States? It would seem that the same logic which led to the recent movement to erect cotton mills near the fields of cotton would apply in this case also. We have a great advantage over the foreign manufacturer if we will only make use of it. When the German or English rosin oil manufacturer gets the rosin thoroughly melted in his still he is just at the point where we were at the moment the molten rosin was turned out of our turpentine still into the vat. Meanwhile what has happened? The heat stored up in the molten rosin has gone to waste, there has been added the labor of dipping it from the vat into the barrels, the cost of inspection, broker's commissions, transportation costs, labor in getting the rosin from the barrels and breaking it into lumps of suitable size for the still, and finally the cost of fuel for again melting the rosin, and why? All in order to get it

back again into the condition in which we once had it. Many industries have been developed on a much narrower basis of saving than that just indicated. Adjacent to each of our turpentine stills there should be found one or more for rosin oil, placed on a lower level, so that the molten rosin could be run directly from the one to the other and destructive distillation of the rosin begun. The stills for rosin oil being made of iron are not expensive and the skill required for distilling is far less than in the distillation of crude turpentine. Again, but little labor would be required, nor would it be necessary to find markets or uses for the products: these already exist and are constantly increasing. With such manifest advantage we should be able to locate the whole of this industry in our midst.

VOL. XXIII JUNE, 1907 NO. 2

JOURNAL

OF THE

Elisha Mitchell Scientific Society

ISSUED QUARTERLY

CHAPEL HILL, N. C., U. S. A.

TO BE ENTERED AT THE POSTOFFICE AS SECOND CLASS MATTER

Elisha Mitchell Scientific Society.

CONTENTS.

Journal of the Elisha Mitchell Scientific Society—Quarterly. Price, \$2.00 per year; single numbers 50 cents. Most numbers of former volumes can be supplied. Direct all correspondence to the Editors, at University of North Carolina, Chapel Hill, N. C.

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VOL. XXIII NO. 2

PROCEEDINGS OF THE NORTH CAROLINA ACADEMY OF SCIENCE, SIXTH ANNUAL MEETING, HELD AT CHAPEL HILL, MAY 17TH AND 18TH, 1907.

The executive committee met Friday, May 17th at 1 p. m., the following members being present: Collier Cobb, W. C. Coker, John F. Lanneau, and F. L. Stevens.

The following names were proposed for membership to the Academy and were elected to membership by the executive committee: Dr. C. H. Herty, Chapel Hill; Dr. J. H. Pratt, Chapel Hill; Dr. A. S. Wheeler, Chapel Hill; Dr. J. E. Mills, Chapel Hill; Dr. R. O. E. Davis, Chapel Hill; N. C. Curtis, Chapel Hill; J. G. Hall, West Raleigh; H. W. Smith; W. A. Withers, West Raleigh; Dr. G. A. Roberts, West Raleigh; F. P. Drane, Chapel Hill; R. T. Allen, U. S. Geological Survey; J. E. Pogue, Jr., Chapel Hill; Miss Daisy B. Allen, Raleigh; Louis W. Gaines, Wake Forest; W. N. Hutt, Raleigh; J. J. Wolfe, Durham; M. H. Stacy, Chapel Hill; Clifton D. Howe, Biltmore; C. W. MacNider, Raleigh: Will L. Brewer, Greensboro.

At 3 p. m. Friday, the 17th, the Academy was called to

Printed June 17.

order by its President, Professor Collier Cobb, and an address of welcome was extended to the Academy by President Francis P. Venable, of the University of North Carolina. A response to the address was made by the retiring President, John F. Lanneau, of the Academy of Science. The remainder of the afternoon session was devoted to the presentation of papers.

At 9 p. m. the Academy met in Gerrard Hall, and the presidential address, "The Garden, Field, and Forest of the Nation," was delivered by President Cobb. Following this address a reception was extended the visiting members in the Y. M. C. A. building.

Saturday, May 18, at 9 a. m., the Academy convened for a business meeting. The minutes of the last meeting were read and approved, and the names of the new members, as elected by the executive committee, were read and formal vote of election to membership was made.

The nominating committee, previously appointed, presented for election the following names: President, T. Gilbert Pearson; Vice-President, W. C. Coker; Secretary, F. L. Stevens; members of the executive committee, Franklin Sherman, Jr., J. J. Wolfe, and John F. Lanneau. It was moved by F. L. Stevens that the name of E. W. Gudger be substituted for that of F. L. Stevens for Secretary. The amendment was carried. These nominees were then elected to office for the ensuing year. The report of the Treasurer, showing a balance of $122.53, was received. Raymond Binford and Franklin Sherman, Jr., were appointed as auditors. It was moved and carried that the executive committee be requested to hold the meeting next year two weeks earlier than that of this year.

Following the business meeting was held a meeting for the presentation of papers.

The following papers were presented:

1. The Sparsity of the Stars, the Measureless Remoteness of

each Star from All Others, John F. Lanneau, Wake Forest College.

The paper will appear in full in Popular Astronomy.

2. The Foundations of Geometry, Archibald Henderson, of the University of North Carolina, published in The Journal of the Elisha Mitchell Society, May, 1907.

3. Some New Sources of Light, C. W. Edwards, Trinity College. Read by title.

4. Some Interesting Grasshoppers (and Their Relatives) of North Carolina, Franklin Sherman, Jr., State Entomologist.

5. Osteogenesis Imperfecta (with a report of a case), Lewis M. Gaines, of Wake Forest College. Read by title.

6. Notes on the Cultivation of Algae for Class Use, F. L, Stevens, of the North Carolina College of Agriculture and Mechanic Arts.

Suggestions were given for the isolation and cultivation of algae upon solid medium, consisting of 75 per cent, ager made up with Knopf's solution. This medium solidifying at lower than 34 degrees, can be safely used in plating out algae. Cultures of several forms were exhibited.

7. Fusion of Sponge Larvae with formatión of composite sponges, H. V. Wilson, of the University of North Carolina.

The ciliated larvae of silicious sponges (Stylotella) may be made to fuse, thus giving rise to composite sponges. To accomplish this result it is only necessary to bring the larvae in close contact at the time when the ciliary action is no longer locomotary and fixation is about to occur. The composite masses representing (in the actual experiments) from two to six larvae complete the metamorphosis.

8. Wind-polished pebbles, and Palaeolithic Man, Collier Cobb, of the University of North Carolina.

The close similarity between pebbles faceted and polished by the sand-blast and the implements of early man was indicated, and the errors which might result from superficial observation were pointed out.

9. Notes on the Zoology of Lake Ellis, C. S. Brimley, Raleigh, N. C.

The paper discusses the occurrence of various insects and reptiles taken by the writer and others in the vicinity of Lake Ellis, Craven County, N. C., during June, 1905, and May, 1906. The rare salamander, Stereochilus marginatus, which had not been taken for many years, was found to be common, and several specimens of the frog, Rana virgatipes, were taken. Nine alligators were secured on the two trips by the author's companion, and several rare snakes. Five species of dragon fly, new to North Carolina, were secured, and (in June, 1905,) numerous specimens of the yellow fly (Diachlorus ferrugatus). Notes on other members of the Tabanidae are also given.

10. Single Phase Railway Work, J. E. Latta, of the University of North Carolina.

11. The Relation of the Cattle-tick to Southern Agriculture, Dr. Tait Butler, State Veterinarian, Raleigh, N. C.

12. The Design of High Masonry Dams, William Cain, of the University of North Carolina.

The method of finding the resultant of the water pressure and the weight of masonry pertaining to any horizontal joint of a dam is given; also the decomposition of the vertical component of this resultant along the joint according to the usual hypothesis. The hypothesis of the conservation of plane sections, in the case of a battered wall, is then criticised and the resulting vertical unit pressure at a face of the

wall, shown to be too high and therefore on the side of safety. But since the pressure near a face, acts necessarily parallel to that face, the vertical unit pressure just computed, is not the whole pressure.

The difficulty of computing exactly this whole pressure is next entered into and an upper limit found by an approximate method which again gives an excess pressure.

Rankine's suggestion, to use the ordinary formula for vertical unit pressure, but specify higher limiting unit pressures for the up-stream face than for the down stream face is adopted provisionally.

The claim is made that, in addition to the three universally imposed conditions, no tension, safe unit pressures and no possible sliding at any horizontal joint—a fourth condition must be imposed, viz., that the factors of safety against overturning and sliding shall increase gradually from the base upwards to allow for the proportionately greater influence, on the upper joints of wind and wave action, floating ice or other bodies, and especially of the great forces caused by the expansion of thick ice under an increase of temperature and by earthquakes.

It was found that this could easily be done by taking the well-known theoretical triangular type of cross-section of dam and making some additions at the top sufficient for a roadway.

A preliminary design is given for a dam 258 feet high, with factors of safety and unit pressures marked on the drawing, satisfying all four conditions. The area of cross-section and height being the same as for the celebrated Quaker bridge design, a comparison was instituted, unfavorable to the latter, in that its factors of safety are too small, particularly in the upper portions, where by the proposed fourth condition they should be largest.

This criticism owes its significance to the fact that the new Croton Dam of New York, 224 feet high to water surface and finished February 1st, 1906, at a cost of over $7,500,000, has

a profile for 224 feet in depth, exactly the same as the Quaker bridge design for the same depth.

Engineering News for June 30, 1888, January 12, 1893, and May 9, 1907, is referred to for the destructive action of ice on ponds, lakes, and rivers, due to the expansion from an increase of temperature during the day. At night, contraction causes cracks to form, often several inches wide, which are filled up with new ice and thus the effect, from day to day is cumulative and very destructive as far north as Canada and in the Northern States. As yet, the action of ice on high dams has not received much attention.

For earthquake action on houses, Milne is referred to; also a personal experience of the author in Charleston, S. C., is recited. It was pointed out, however, that dams being built into the sides of the valley at their ends, were not so free to move at their tops as houses.

A brief description and analysis of the failure of the Habra dam concludes the paper.

13. Three Little Known Species of North Carolina Fungi, J. G. Hall, of the North Carolina Experiment Station.

14. A New Form of Achlya, W. C. Coker, of the University of North Carolina.

During the fall of 1906 an Achlya was found at Chapel Hill, N. C., which agrees with *Achlya racemosa*, var. stelligera Cornu, in many respects, but different from it in having the autheridum cut off immediately below the oogonium, and the fertilizing tube arising from the division wall and entering the oogonium from below, as in Saprolegnia hypogyna Pringsheim. Such an origin for the fertilizing tube is new for the genus Achlya, and is not known elsewhere except in Saprolegnia hypogyna.

15. Notes upon the Preparation of the Silicate Medium for the Cultivation of Bacteria, J. C. Temple, N. C. Agricultural Experiment Station.

Directions were given for the preparation of this medium obviating the necessity of dializing, and making it possible to prepare this medium with greater certainty and greater accuracy. The use of the medium prepared in this way for the culture of various organisms was illustrated by colonies of various bacteria growing in a thriving condition upon the medium.

16. Breeding Colonies of Birds (Illustrated with Eggs and Stereopticon views), T. Gilbert Pearson, of Greensboro.

17. The Efficiency of Soil Inoculation in the Production of Root Tubercles, F. L. Stevens, of the North Carolina Agricultural Experiment Station.

Data was given concerning the inoculation of soils with liquid cultures obtained from the Department of Agriculture, Washington, D. C. From many tests conducted in various ways there was no evidence whatever that inoculation with these cultures was efficient in the production of tubercles upon the legumes. The cultures employed were issued in liquid condition in hermetically sealed test tubes, and were obtained directly from the Bureau of Plant Industry, Washington, D. C.

18. The Opportunities for Study and Research at the Beaufort Laboraty, H. V. Wilson, of the University of North Carolina.

19. Does Blood Tell? Heredity According to the Experience of the Children's Home Society, William B. Streeter, of Greensboro, N. C.

20. Geology of the Cape Fear River, Joseph E. Pogue, Jr., of the University of North Carolina.

21. The Relation of Sporangium of Lygodium to the Evolution of the Polypodiaceae, Raymond Binford, of Guilford College.

22. The Condensation of Alipatic Aldehydes with Aromatic Amines, Alvin S. Wheeler, of the North Carolina University.

The following reaction takes place without any dehydrating agent: $RCHO+2RNH_2=RCH(RNH)_2+H_2O$. In some cases at low temperatures the addition product is obtained. Condensation products of Chloral with the three nitranilines, p-bromaniline, o-toluidine, anthranilic acid, and o-anisidine were prepared. By-products, as yet unidentified, were obtained with o-toluidine and with anthranilic acid. The condensation products are readily broken down by Hydrochloric acid and by acetic anhydride. When suspended or dissolved in the glacial acetic acid they react with extreme smoothness with bromine, forming beautifully crystalline compounds which are much more stable than the condensation products.

23. Chapel Hill Ferns, by W. C. Coker, of the University of North Carolina.

A collection of the living ferns and fern allies native to Chapel Hill, N. C., was made and exhibited in pots. Twenty species were represented, including all the known Ptridophytes of the neighborhood, except Botrychium ternatum and its variety, dissectum, which had not yet appeared above ground.

24. Notes on Turtles of Genus Pseudemys, C. S. Brimley, of Raleigh, N. C.

25. Electricity in Heavy Traction (Illustrated by lantern slides), J. E. Latta, of the University of North Carolina.

26. The Optical Rotation of Volatile Oil, C. H. Herty and G. A. Johnson, of the University of North Carolina.

27. Children's Home Society Methods, William B. Streeter, of Greensboro.

28. Gametophytes of Botrychium Virginianum, Raymond Binford, of Guilford College.

They were found in moist oak woods under the leaves. Some were almost on the surface of the soil while others were imbedded one to two inches in the soil. They seem to have gotten down by means of worm holes or cracks made by roots of trees. Sizes ranging from 2 m. m. to 10 m. m. were shown. Specimens of these plants were exhibited before the Academy.

A motion of appreciation of the courtesies extended to the Academy by the members at Chapel Hill and ladies of Chapel Hill was unanimously carried.

At 1:30 o'clock Saturday the Academy adjourned.

F. L. STEVENS, Secretary.

THE GARDEN, FIELD, AND FOREST OF THE NATION.

BY COLLIER COBB.

(Address as President of the North Carolina Academy of Science.)

It has been the boast of more than one of our politicians that North Carolina could well be independent of the rest of the world, for we might enclose the State with a high wall and get along just as well, since we produce within our borders everything that we need. This boast was based on the fact that North Carolina puts something in every column of the blanks sent out by the Agricultural Department at Washington, that she produces a little of everything; but the inference drawn from this fact is far from being true. Not a single county in the State produces food-stuff sufficient to sustain its population. As our towns and cities have grown, the relative food production has diminished, and in most of our counties this diminution in the amount of food produced has been not only relative but absolute.

For the last score of years the population of our towns and villages has increased as families have gone from the farms to the factories, often to live off the labor of the children, or from the rural districts to the city in order to give the children better schooling. The increase of our population from outside sources, too, has helped to swell the urban population. But farm lands are not increasing, the acres planted with food stuffs have steadily diminished in number, and under our old system of cultivation there has been a steady diminution in the value of the returns per acre. Even

Orange County, which may be reckoned a rural district, does not begin to make food enough to maintain its inhabitants through the year, and the inhabitants of our adjoining county of Durham would starve in less than a fortnight if they had to depend on the food product of the county for support. When some of us in this hall came to college the village of Durham could claim no other distinction than that of being the railway station from which students drove to Chapel Hill. Today it is a city of more than 20,000 inhabitants, drawing its population from all parts of the world, and dependent upon distant fields for its support. And not one of our large cities, Wilmington, Charlotte, Asheville, Greensboro, or Raleigh, could depend on its own county, or even upon the surplus of a score of adjoining counties, for its food.

Notwithstanding the several years of unprecedented crops that we have had, amounting almost to seven years of plenty, we are practically face to face with a famine. The wheat lands of our own Northwest have been practically exhausted of their lime, as an acre of wheat will use up ten pounds of lime in coming to maturity; and this loss, added to the damage done the soil by the poisons excreted by the roots of the wheat, has caused our farmers of the great plains to seek new fields in the Canadian West. Already the natural pasturage of our semi-arid regions has been practically exhausted, and neither cattle-raising nor sheep-raising is profitable, where within two decades vast fortunes have been made in these industries. Those of you who paid your month's butcher's bills on the first of May were doubtless led by their unusual size to investigate causes, and learned that for the first time in the history of the Chicago and Kansas City packing houses they have not been able to fill their cold storage. The demand of the country for fresh meat has consumed the entire output of these houses during their busy season. And this state of things has come about after three years of abundant crops, during which time the packing

houses have paid their own prices for meat. Now let a drought come and there is absolutely no escape from a meat famine.

But what are we going to do about it? What is the solution of the problem? We are all familiar with the fact that in our older States of the South the annual product per acre has greatly decreased, owing to the rapid loss of soil fertility, and that even our moderate production is maintained only at increased cost; and also, that the comparatively new States like Texas, as well, show a rapid deterioration of land and loss of fertility. And it may be pointed out that our farmer is of all men most miserable; neglected and looked down upon; slave to the credit system; servant where he should be master; poor and becoming poorer; the prey of sharpers; the disconsolate follower of a calling which he has inherited with his deteriorating acres, clinging to the past, knowing no higher law than chance, planting, rearing, and gathering his crop under the leadership of luck, each succeeding year seeing his granary heaped fuller of disappointments, leaving him poor in purse and lean in hope. None of us can deny that this is a true picture of the average farmer of our State as we have known him from our youth up. The politician who has flattered him biennially that his calling, seen in its true perspective, is outranked by no other in power, scope, or service to mankind, has gone his way and made laws directly opposed to all the farmer's interests.

Still, what are we going to do about it? How are we to escape famine if our present source of supply should be exhausted? What is the solution of the problem? Increase the output from the soil that we have by the application of science—"that sensible science of our day which has for its ultimate aim not merely discovery but application; which is not so delighted by the formulating of a new law as it is overjoyed at the lifting of a burden;" science, in which laboratory investigation goes hand in hand with field experimentation, the science of our present time, which is applied

common sense, combining laboratory practice with business-like methods. Such science our United States Department of Agriculture is engaged in and encouraging; so also the various State agricultural experiment stations and most of the agricultural colleges, corn breeders' associations, truck growers' associations, sugar producers, tobacco growers, private investigators like Luther Burbank, all laboring to lift the burden from the agriculturist, and make him indeed what the politician has been flattering him that he is. Greater progress has been made in all departments of life dependent upon the soil in the last score of years than in the previous two score centuries.

The most important of all this service of science to the farmer bas been the study of the soil, the fundamental factor in all the varied lines of life that branch out from agriculture. How to save it, how to nourish it, how to restore it to life when dead, what it is composed of, how it is formed, how to interpret it so that any man may understand it—these have been, and still are among the great problems before us. Their solution is being worked out and already that work has revolutionized agriculture within our own State and is slowly changing conditions for the better in the entire South.

Tobacco is grown in eastern North Carolina today because a soil investigator found out that the marls just beneath the soil there contained in available form the lime that the tobacco plants require for their growth, and of course all the other essential minerals are there. Hitherto tobaccos had been grown on limestone soils, or on soils derived from igneous and metamorphic rocks rich in lime-soda feldspars.

In a similar manner it was discovered that the sands of the sand-hills regions of the Carolinas contain both lime and potash in available form, whereas similar sandy soils of Western Europe are practically devoid of these necessary plant foods, but this soil is particularly adapted to the growth of the vine, and in consequence an important grape industry has grown up in our sand-hills district.

Similarly it was found out that certain incoherent white quartz sand in Florida was valuable pine-apple soil, notwithstanding it was over 99.5 pure quartz, because it possessed certain properties that the bacteriologist discovered.

Investigation showed that the soil of the Connecticut Valley, which produced only low grade tobaccos, sneered at as Connecticut cabbage leaf, was essentially the same as that which produced the Sumatra tobacco. But it was necessary to change the climatic conditions, and this was done by the use of cheese-cloth, increasing the humidity and raising the mean temperature ten degrees Fahr. Somewhat similar experiments have been tried in Darlington District, South Carolina, the result, so far as the production of Sumatra wrappers was concerned, being entirely satisfactory. And such investigations and experiments have been carried on all the way from Connecticut to Alabama and Texas with the result of greatly improving the product and greatly increasing the output, producing in the Southern States the cigar tobaccos of all lands.

This matter of the investigation of soils is by no means new, though its methods and their application to agriculture are matters of little more than a decade. Such investigations were begun by Liebig at Giessen more than half a century ago. He and his assistants made countless analyses of the ashes of plants. These showed the presence of different minerals in every species, that each species requires from the ground the same class of salts, and hence that it must sooner or later exhaust the supply of these salts in a given plot, and render it unfit for the growth of the species in question unless fresh supplies are provided.

"Liebig attempted to give the necessary supplies in the form of 'Mineral Manure', and soon set to work to study practically the effect of mineral manures on a large scale. In the year 1845, previous experiments in a garden having proved unsatisfactory, he purchased from the town of Giessen about ten acres of barren land—a sand pit, as he says, which

surpassed all the land in the neighborhood in its barrenness for ordinary cultivated crops; in the year this land hardly grew so much fodder as would have sufficed for a single sheep. It consisted partly of sand, partly of coarse quartz and pebbles, with strata of sand and some loam.

"Some of the soil was first tested by sowing it with seeds in pots after enrichment with some single mineral manure, with the result that not one of the plants got beyond flowerering; this showed that the soil was bad enough for his purpose of testing the value of minerals as manure.

"A number of mineral manures were then prepared for him according to prescriptions based on his analyses, and these were spread over the land; next he sowed on different subdivisions of it wheat, rye, barley, clover, potatoes, turnips, maize. In some cases he added sawdust to the manure, and in one case he used stable manure; otherwise no ammoniacal manure and no mineral matter was employed, except that to one plot he applied some forest soil and to another a mixture of forest soil and mineral manure. Even in the first year he had a harvest; the best results were given by those plots in which mineral manures were mixed with forest soil or stable manure. This, as he says, enabled him to correct his earlier ideas of the functions of humus, which by its decay renders an extra supply of carbonic acid gas to the plants that is especially valuable at the early stages. Gradually, without any other supply of manure except mineral manure, the land so improved in productiveness that in the fourth year his crops excited the wonder of all who had known the original state of it.

"In 1849 this little farm was purchased by his gardener, who was then able to farm it with profit, raising some cattle on it yearly and getting such satisfactory crops of corn that in 1853 a neighboring farmer wrote: 'With us the wheat crops are very poor, but on the height (Liebig's plot) they have harvested three fuder of rye twelve simmer, while I from three fuder of the best rye, have only got five simmer,

If you were to see it, you would be astonished; it is truly wonderful.' "

From his experiments with this land Liebig was led to form the opinion that it was possible, by giving the soil proper physical quality and composition, to bring about a state of things in which sufficient ammonia to maintain its fertility can be collecteed or condensed from the air. He recognized not only that certain elements were necessary in a fertile soil, but more—and what certain soil chemists have been slow to recognize—that these elements must occur in certain combinations as minerals to be available as plant-food. He found, too, that certain earths and other substances might be added to soils, which would withdraw to some extent soluble salts from their solutions, removing from the soil substances injurious to plant life. Liebig was greatly interested in the experiments made in England by Sir Thomas Way on the absorptive power of soils, and was the first to recognize the true value of these experiments to agriculture.

Thus it was that a chemist sixty years ago recognized that the study of soils was as much the province of the geologist, the mineralogist, and the physicist, as of the chemist; and the work with which he is credited in Denmark shows that he also regarded it as within the province of the botanist. So greatly did he value the structural features and mineral composition of a soil as indicators of its fertility, that he said: "In matters of this kind the farmer must pursue his own course..............he must not put the least faith in the assertion of any foolish chemist who wants to prove to him analytically that his field contains an inexhaustible store of this or that nutritive substance."

In other words, Liebig saw that it is not so much the chemical elements in a soil as their mineral combination which determines their available plant food, and the geologists have found that very different rocks may be made from the same molten magma under different conditions of cooling. And it was Liebig who pointed out to the farmers that they

might change the fertility of their soil by changing its texture. In examining into the improved conditions of agriculture in the dune districts of the Jutland Peninsula a number of years ago, I found that the farmers of that country attributed their prosperity wholly to the suggestions made to their fathers and grandfathers by Liebig who went to Denmark to study moving sands; but I have not been able to find that he ever published anything on the subject.

But the dream of Liebig is being realized, and the study of soils is enlisting the closest attention of the chemist, the geologist, the mineralogist, the bacteriologist, the botanist,—a relatively small but powerful coterie of men who are the investigators and interpreters of modern agriculture. The chemist has found the essential plant foods, the geologist has noted the natural distribution of vegetation with relation to rocks both as to composition and structure, the mineralogist and geologist have studied the rock-making minerals in relation to their available plant-foods, the bacteriologist has shown us that certain living organisms in the soil are of enormous importance to every man who raises food for man and beast, the botanist has busied himself with breeding certain plants adapted to certain soils. "Knowledge is now no more a fountain sealed." The farmer of to-day may, nay he must, come up to his calling "as fully equipped for service as the lawyer, the editor, the doctor, the captain of industry; for the curious fact has developed that the calling in which the unlettered and untrained man was once supposed to have as good a chance as the educated one, is now the calling in which wide and varied knowledge is almost as imperative as in almost any other known among men."

Of the more than seventy elements that make up the crust of the earth only about a dozen are essential to successful agriculture and practically all soils contain these in one form or another. Only four of the twelve—nitrogen, phosphorus, potassium, and calcium—are liable to be lacking in

any given soil. But when any one of these four is wanting dire results follow.

The results that may be obtained, even where all these elements are present in proper proportion, depend upon the size of the soil particles, upon the number of grains of soil in the little measure of a gram; for the freedom with which the film of soil moisture moves over the soil grains determines the amount of plant food taken out of the soil. If the farmer is a raiser of truck for the early market, the soil for his lettuce, peas, beans, onions and radishes must be of a certain well-defined structure—it must have at least one billion, nine hundred and fifty millions of particles in a gram, in less than a thimbleful of earth. If he is going in for ordinary summer and autumn vegetables, corn and cabbage and potatoes, then there must be at least two billion additional particles in each gram of soil. If he is a wheat planter he must be sure that there are not less than ten billion, two hundred millions of particles in his little thimbleful of soil; while for wheat and grass land combined the soil must be in finer particles still.

While it has been known for at least two centuries that bacteria exist in the soil, it is only recently that they have been studied with any degree of satisfaction. They exist everywhere in earth and air and sea. They were believed at one time to have animal life, but they are now almost universally accepted as low forms of vegetable life. Over a thousand different kinds are now known, and the list is being steadily added to as knowledge of them increases. They increase by dividing themselves in two, and this they do at a marvelous rate of progression. One of them, according to a bacteriologist who has studied it closely, would, if left to itself, produce seventeen million descendants in twenty-four hours. Another scientist calculates that another particularly rapid multiplier could produce, if it had penty of food, four thousand seven hundred and seventy-two billion progeny in a single day. They differ from plants which we see growing

about us in that they have no chlorophyl—the material which gives the green color to the plants.

In a Kansas soil it was found that there were as many as one billion, six hundred and eighteen million, six hundred and eighty-one thousand, eight hundred and ten bacteria in a single gram or small thimbleful from a field under examination, while another field nearby had only a few over a million. As air is necessary for their existence, they rapidly decline in numbers as you go down in the soil to a point where none is ever found.

Many different families of these bacteria live in the earth, making their homes in the soil. They help to decompose it, thus transforming it into food. They draw vast stores of food supplies from the air. At every point they act as agents in advancing the interest of man.

Four-fifths of the air we breathe is one of the most valuable plant foods, nitrogen. Some of this nitrogen is available in one form and some in another, but it must all be put into such form that it may pass into the system of the plant and be utilized in the building up of stalk and leaf and ripened seed.

In portions of North Carolina I have seen a field worn out by injudicious cropping, the plants struggling to grow in a depleted soil into what would be at best but a lean and starved maturity. In an immediatly adjoining field, with a soil of precisely the same character, with no advantage in point of moisture, heat, or sunshine, with precisely the same kind of seed planted as in the first case, were tall, strong, and thrifty plants, neighbors to the thin, yellow, beggarly ones of the first field.

The only difference between the two was that when the seed were planted there was sprinkled in the rows of one field some plain simple dirt brought from another State, and the field that had this dirt sprinkled in its rows was the field with the strong and vigorous plants. What wrought the wonderful change was a colony of nitrifying bacteria, living,

moving things, that helped the crops to get their nitrogen from the atmosphere. Long ago it was discovered that certain plants, as the beans, clovers, peas, vetch, alfalfa, and the like, form upon their roots little bunches of tubercules, as they are called. When science sought out the meaning of these tubercules, why they formed on these particular plants, what purpose they served, it was seen that they were not abnormal, but necessary, and that plants that had them were more thrifty than those that had them not. It was discovered that their task was to take nitrogen from the air and transform it into nitrogen suitable to be taken up by the plant.

Having learned, then, the soil conditions necessary for plant growth, the next thing is to apply them.

Residual soils, those found upon the rocks from which they are derived, have certain definite characters determined by the characters of the rocks beneath, and they are not apt to deteriorate, since their source of food-supply is immediately at hand, unless the fine particles are carried away by erosion faster than the rock beneath can rot into soil. Transported soils, on the other hand, are very readily exhausted, since they are far removed from the parent rock, and they need to have their supply of plant-food constantly replenished by the use of fertilizers. One way of keeping up the fertility of the soil is by rotation of crops requiring different plant-foods.

The best way to farm is to plant in each field the crop to which the soil of that field is by nature best adapted.

But we often desire, or actually need, crops to which the soil of a given district is ill-adapted. Since we cannot change the soil materially, the difficulty is met by breeding plants to suit the soil, and what has been accomplished in this direction is little short of miraculous.

The wasting of soils where serials are grown, and the gradual reduction, year by year, in the yield of these crops, has led more than one thoughtful student of human condi-

tions to predict a time, and that not very far distant, when there will not be bread enough to go around.

While enough has been done in the restoration of worn out soils to show that the time is farther away than was at first feared, much more has been done in the breeding of new varieties of wheat and corn to take the place of the old and unsatisfactory ones. New wheats have been created not only showing larger yields and as great nutrition in experimental plots, but in the thousand-acre farm of the advanced American Agriculturist as well. More than this, wheats have been bred to fit a climate, redeeming vast areas of abandoned land supposed to be wholly unfit for wheat production.

New corns have been created, far richer in food values, far larger in yield, than the best known types of the past. More than this, corns have been created at the command of man for any one of a series of specific purposes—to be rich in one element and lean in another, to be food for man or food for beast. They are, in a word, as much the creation of man as the beautiful vase in the hands of the potter.

The experiment station of the University of Tennessee determined to breed a wheat that should fit the soil and climate of that State, where no wheat would grow and produce good results. When the experiments were begun, eight bushels to the acre was a fair average yield. After several years of testing, breeding, and selection, they have produced a wheat that has produced as high as forty-eight and one-half bushels per acre on the same land, while maintaining an average of over thirty-seven bushels for a period of four or five years. And we in North Carolina have reaped the benefits of this and similar experiments elsewhere in the extension of wheat producing area to the poorer lands of the eastern part of the State.

When we consider corn, the greatest cereal in point of value of annual production in the United States, the results achieved are even more satisfactory. The object sought in breeding new corns was not only to produce corn with a heavier yield,

but to change the character of the corn itself. Corn for human food should be rich in one element. Corn for manufacturing into any of the various products which are now made from it should be rich in certain other elements.

So the corn kernel was studied in order to find out precisely what it was made of, that by selective breeding this might be changed. By taking kernels from a series of ears known to be rich in one particular element, and breeding from these ears year in and year out, carefully selecting for future seed only the richest and best kernels and only those approaching the ideal established, little by little, with infinite pains and patience, new corns have been built up having the desired character and composition.

A manufacturer desires corn for the production of oil, now one of the most valuable products of the corn plant. It is in large demand among the olive-oil manufacturers of Europe. The oil comes from the fat in the tiny germ of the corn, and the larger the germ the greater the supply of oil. Corn-oil is in demand for many other purposes, and it appears to be but at the beginning of its commercial life. Hopkins in Illinois has succeeded in producing a corn relatively much richer in oil than any that has preceded it, one having 6.96 per cent. oil while the corn with which he started only six years before contained only 4.7 per cent. of oil. To some manufacturers the fat of the germ is not essential, so, to accommodate these, he reversed the process and bred a corn low in fat or oil, reaching 2.99 per cent.

The element of the corn which is most valuable for strengthening food, which is the muscle-building material of all food, has also been increased at will, and where it could make way for some other element suitable for some other purpose, it has been decreased. All this has been accomplished by selective breeding. Corn has been produced having 16.11 protein, a remarkably large amount, while the protein has been reduced to 6.66 per cent., a difference in protein of nearly ten

per cent. Corn is also bred for a large amount of starch, and similarly useful results follow.

The breeding of corn has gone to yet another extreme, the breeder having succeeded in doing away almost entirely with the grain and producing a large, firm cob. These cobs, that are produced on some of the poorest land in Missouri, are used for making the corn-cob pipe, and the introduction of the Collier corn into that district has been a Godsend to the poorest farmers with the poorest lands in the State. A very similar result has recently been obtained in Illinois, where a large firm cob with an insignificant grain has been produced on a soil of nearly pure siliceous sand. It has been found that the pith of the corn cob is a most valuable substance for calking ships and stopping leaks, the pith absorbing water and swelling to fill the crevice, and corns have been produced with a maximum of pith in the cob.

The corn of our mountain districts is rich in fat, and there too is the only portion of the South where we may raise sugar corn with success. The longer season in the lowlands admits of the elaboration of the fats into proteids. It is interesting to note in this connection that the corn of our mountains and the corn of the north are rich in heat producing elements, while these are almost entirely wanting in Southern varieties of corn, the long growing season admitting of the change of the sugars and fats into proteids. We cannot even raise sugar corn in our coastal plain from the seed of sugar corn grown there, but must get our seed each season from a colder region. The same is true with regard to the seeds of cabbage grown in the South except in the mountain region.

The changes in the character of corn are in no small measure the work of members of the corn-breeders' association, and show what may be accomplished through co-operation among farmers. This association has been working to make corn a complete ration. Here in the South, Williamson has greatly improved corn both as to quality and yield per acre, by a method peculiarly his own. The seed has been planted

and allowed to grow with grass and weeds until the plant has reached a weak maturity and is just ready to bear grain. Then the grass is cleared out, the corn well worked and heavily fertilized, when its stimulated growing energy goes all to fruiting. It has its parallel in the intellectual activity of the boy who comes from the back districts where he had no advantages of an intellectual sort, but his energies being aroused at the right moment, often surpasses his more fortunate associates in his college course and in the race of life.

Some of the most interesting experiments in plant-breeding have resulted in the production of food stuffs adapted to semi-arid regions, and these are of especial interest to us for the reason that we have a long strip of semi-arid land in the South, lying mainly in the sand-hills region and immediately bordering that region on the northwest, little more than a barren sand-waste until the introduction of new methods and new plants suited to its conditions.

Alfalfa has been bred to resist both drought and alkali, and it has also been found in nature. Agents of our Agricultural Department searched the earth for what was needed, and found just the thing desired growing in an oasis of the Algerian Sahara. Luther Burbank has bred a spineless and edible cactus admirably adapted by nature to such regions, and this may yet become an important food plant in certain portions of the South.

Rice forms the principal food of one-half the population of the earth. It is more widely used as a food stuff than any other cereal. Where dense populations are dependent for food upon an annual crop, and the climate admits of its cultivation, rice has become the staple food. The luxuriant growth of leguminous plants (peas, beans, etc.) in warm climates provides the nitrogenous elements necessary to supplement rice. A combination of rice with legumes is a much cheaper complete food than wheat and meat, and can be produced on a much smaller area.

The Carolinas in the decade ending 1860 produced approxi-

mately eighty-five million pounds of clean rice. Now the total product for a like period is only about thirty-five million pounds, of which North Carolina only produced about seven million. But the total rice product of the entire South has advanced from 103 millions to 143 millions in the same time, thanks to the valuable investigations of and improved methods introduced by Dr. S. A. Knapp, of the United States Department of Agriculture.

Horticulture is coming to be a most important branch of agriculture, and its surprising progress has already been so fully discussed in our newspapers and periodical literature that I need do little more than advert to it here. Suffice it to say that in 1870 the export of fruits preserved in cans or otherwise from the United States to foreign countries amounted in value to $81,735.00. Ten years later the value of the canned fruits exported had advanced to $371,118.50. In 1890 it was over $600,000.00, and in 1900 had passed two millions. This does not give us any indication of the enormously increasing domestic consumption of fruits.

It is an interesting fact that the traveler of to-day does not find his way across the desert by the bones of men and beasts that have started on the perilous journey before him, but by the shining tin cans left by those who have made the journey in safety.

This progress in fruit growing has been made possible by the breeding of fruits to suit different climates, and by the importation of insects to prey upon the insect enemies of fruit trees.

Already our trucking interests have made the South the garden of the nation, for we have here the broad coastal plain soils that yield readily to cultivation; but business methods have gone hand in hand with the application of scientific methods and are always equally important to the agriculturist. The managers of the truck-growers' association see to it that the crops come on in regular rotation from Florida, Georgia, the Carolinas, Virginia, and Delaware.

The Strawberry Trust at Selma, a North Carolina organization, has an agent who gets each night reports from all the strawberry eating cities as to the number of crates of berries on hand, and he then learns from the fields how many they can supply, and an effort is made to keep the shipments just a little short of the demand. Then by uniting their shipments and sending them forward in carload lots, the shippers get a better rate and quicker transportation.

Notwithstanding the South produces so much rice, and the entire product of the country, still we produce only half of what is consumed in the United States; but with the improved methods of cultivation, it will be but a short time before we produce enough for the entire nation.

Of corn we can produce every variety from our coastal plain to our mountains, and corn culture is extending about as rapidly as the culture of rice. The culture of wheat is extending as new varieties are being bred for our lands, and wheat culture is extending into regions where wheat has never before been raised. New varieties of potatoes have been produced in our potash soils, and already the best of these are grown in the South, and the rapid extension of their culture will soon make us the most important potato producers in the country.

Of cotton, we have not simply the monopoly of this country, but practically the world's monopoly as well. Experiments carried on at Darlington, S. C., have resulted in the production of a long-stapled cotton that will grow far from the sea islands. And the new methods of tobacco culture are showing us that we can produce all the grades of tobacco, and these in any quantity.

Thus we already have the garden of the nation; we may become, nay, are rapidly becoming the nation's field for the production of food stuffs; and whether we will or no, we will soon be the only forest that the nation has left, except in the national forests scattered over our broad domain.

Forest trees depend more directly upon rock composition

and geological structure than any other products of the soil. This is beautifully illustrated in our State where conifers predominate over the coastal plain and sand hills region, and the broad-leaved deciduous trees over the granitic and schistose rocks farther west. Within these areas species and varieties vary with the changes in character of the rock and the change of its dip helping or hindering drainage. This is beautifully illustrated in the neighborhood of Chapel Hill, where our Triassic sandstones bear the loblolly pines, except where the rocks are cut by dikes, and then you may trace the dike by the broad-leaved trees that grow upon it. The crystallines of the Chapel Hill mass have their characteristic diciduous species, and these again vary as the rock structure changes.

We have in the Appalachians practically the only hard wood forests on the continent, and many of the most valuable species are confined to the Southern Appalachian mountains. In the north these forests have been ruined by the destructive work of the lumberman, before the introduction of the methods of modern scientific forestry; but here we already have the forest of the nation if we will but preserve it, and upon its preservation depend the field and the garden.

Our fathers had a true instinct when they pictured a great civilization in the South based upon the soil. Their vision is to be more than fulfilled when Southern agriculture can bring to its aid science, that sensible science of our day, which has for its ultimate end not merely discovery, but application; which is not so delighted with the formulating of a new law as it is overjoyed at the lifting of a burden. "Then the tiller of the soil will come up to his calling as fully equipped for service as the lawyer, the doctor, the captain of industry; for it has come to pass that the calling in which the unlettered and untrained man was once supposed to have as good a chance as the educated one, is now the calling in which wide and varied knowledge is as imperative as in almost any other known among men."

Men have also come to the same views as those expressed by the King of Brobdingnag, who "gave it as his opinion, that whoever could make two ears of corn, or two blades of grass to grow upon a spot of ground where only one grew before, would deserve better of mankind, and do more essential service to his country, than the whole race of politicians put together."

And better still: While the politician of the not very remote past flattered the farmer and yet made laws directly opposed to all his interests, the new politician in the South shows constructive statesmanship by helping him to take advantage of the opportunities around him, helps him with his inland waterways, helps him to preserve his forests.

SOME INTERESTING GRASSHOPPERS (AND RELATIVES) OF NORTH CAROLINA.

BY FRANKLIN SHERMAN, JR.

The grasshoppers and their relatives comprise the order of insects known as the Orthoptera. The entire order contains probably about 150 species native to North Carolina, of which about 130 have now been collected, identified, and recorded.

There are not many students of Orthoptera in this country and what few entomologists there are in the Southern States have neglected the group entirely, hence practically nothing was known of the actual distribution of our species until 1903, when Prof. A. P. Morse, of Wellesley College, made a special tour through the Southern States to study this subject, and, partially through the entreaties of Mr. C. S. Brimley and the author, he devoted more time to North Carolina than to any other State,—traversing it from east to west and then again visiting the high ranges in the western section. During his tour, Prof. Morse spent two days at Raleigh, at which time Mr. Brimley and the author accompanied him in collecting jaunts with the result that our latent interest in this neglected order was considerably aroused. The facts set forth in this paper have, therefore, for the most part, been collected in the last three or four years, by C. S. Brimley, G. M. Bentley, and the writer.

While no one can seriously study this order of insects without becoming interested in the special structures and their use in classification, as well as in the habits of the living insects,—yet there are about a dozen species which would more particularly arouse the interest or curiosity of the ordin-

ary observer, and to mention these is the special object of this paper.

Labidura riparia. This insect belongs to the family of insects known as the "Ear-wigs". The group is abundantly represented in Europe, but only sparsely in America, the few American representatives, however, being more especially distributed in the Southern States. Most of our ear-wigs are of small size, ranging from one-half to three-fourths of an inch in total length. In mid-April of the present year a janitor brought to the office a living specimen of this species, a fine large male, the first to be taken in the State.

Cryptocercus punctulatus. This insect belongs to the family of roaches, a few species of which infest houses, though more are found in the forest. The present species has been taken in four localities in this State, three of which are in the mountains, the exceptional locality being Newton. It is rather a large species, is entirely wingless, and is rather slow and stiff-bodied in movement, in which respect it differs from most other roaches. Our specimens have all been found under logs, in the months of July, August, and September.

Stagomantis carolina. This creature is most commonly known by the names of "Rear-horse", "Devil's Riding-horse", "Praying Mantis", and other expressive common names. It often arouses curiosity by its peculiar appearance and demeanor. It probably occurs throughout the State, at least east of the mountains, though we have had specimens from only a few localities. It is the only member of the Orthoptera in the State which is known to be predaceous in habit.

Diapheromera femorata. This insect is also known by the name of "Walking-stick", so called because its very slender body gives it a resemblance to small twigs, and because the insect always deliverately *walks*, and never runs or jumps. All through the summer the young insects are greenish in color, corresponding to the color of young twigs and the petioles of

leaves among which they live, but in the autumn when the leaves fall and the twigs become gray or brown, these insects, being then near maturity, turn gray in color. These remarkable resemblances, combined with their deliberate movements, render them quite difficult to detect, unless they force themselves accidentally upon one's notice.

Eritettix navicula. This is one of the true grasshoppers, which so far as has been observed inhabits rather low, grassy grounds. It is an exception in that it is the only species which has the antennael enlarged into a knob or club, at the tip.

Trimerotropis saxitalis. This very remarkable grasshopper is an inhabitant of the exposed, lichen-covered surface of the rocks on some of our mountains. In his trip through the Southeastern States Prof. Morse failed to take it in this State, but recorded its presence on the summit of Stone Mountain, in Northern Georgia. In September last (1906) Mr. Woglum and myself took it quite commonly in favorable spots on the summits of Satula and Whiteside Mountains, near Highlands, Macon County. The species bears a remarkable resemblance to the lichen-covered rocks on which it is found, and when flushed will invariably settle again on the rock, it being only in most exceptional cases that they could be persuaded or forced to alight in grass or herbage. When cornered they would quickly fly back within a foot or two of the collector to again reach the rock, although the species is quite shy when once disturbed.

Leptysma marginicollis. This species is found in grassy places where it clings to the upright stalks or blades, so closely applying its body to the grass as to render detection difficult, both the shape and color of the insect being protective. One remarkable feature of this insect is the fact that the front of the head (or face) slopes away under the body in such degree that the mouth is situated almost between the front legs.

Melanoplus punctulatus. The genus Melanopsus contains many species, the majority of which are not especially striking in appearance or habits, but this species is an exception in that, while all the other species habitually live on the ground or on low-growing grass or herbage, this one is considered to be strictly arboreal, occurring on trees, stumps, shrubbery, etc. Our one specimen of this species was taken in Transylvania County by Mr. Woglum, and is mottled in appearance, which renders its color protective when on lichen-covered bark. It is likely that the species does not occur east of the mountains in this State.

Dissoteiria carolina. This is one of our most common grasshoppers, and in nature (if not in the cabinet) is surely familiar to most observant country people in this State. Among those who have any common name for it, it is known as the Carolina Locust. It occurs throughout the State along roadsides and in cultivated fields. The remarkable thing about this species is the variability of its protective colors. In sections where the soil is grayish in color there the insect is grayish, while only a mile away may be found red clay soil and grasshoppers of a decidedly reddish tinge. Not that the resemblance is perfect, but the difference in color of specimens taken on differently colored soils is quite noticeable. On one occasion in Raleigh I took a specimen on a railway embankment and the greater portion of the body was blackish to correspond to the soot and cinders among which it was found, No similarly colored specimen has since been taken anywhere, and others were not seen at that time.

Gryllotalpa borealis. This is commonly known as the "Mole-cricket", so called from its habit of burrowing in the ground like a mole, and from the further fact that it has developed along very similar lines, the front limbs being much enlarged like the front paws of the mole, and like them are used for digging.

Myrmecophila pergandei. This small and wingless cricket

is found beneath stones in company with ants, whose nests they inhabit, and in cousequence of the darkness prevailing in its usual haunts, is white in color. Thus far it has been taken only at Raleigh, though doubtless it occurs in other localities.

Tridactylus sp. This is a small, blackish species taken at Raleigh early this month for the first time. It was found in low,sandy ground in which it frequently disappeared down very minute burrows. When disturbed or alarmed they jump with marvelous agility, their small size causing them to instantly disappear from view when they once leap away. After capturing several specimens by laboriously approaching them with the killing bottle, we finally began to walk rapidly over the ground and sweep the collecting net back and forth at random, and by this means secured them in considerable numbers.

NOTES ON SOME TURTLES OF THE GENUS PSEUDEMYS.

BY C. S. BRIMLEY.

The genus Pseudemys comprises a number of large fresh water turtles found in the streams and ponds of North America. These have the carapace marked with a more or less variegated pattern of light and dark colors, and are distinguished from allied genera by the broad masticating surfaces of the jaws, which are in the upper jaw divided by a longitudinal ridge parallel to the margin.

The species dealt with in this paper fall more or less naturally into three groups, which are characterized as follows:

Group I. Upper jaw with a notch at the symphisis and a cusp or tooth on each side of the notch. Lower jaw, at least, strongly serrated. Ridges in masticating surfaces of jaw tuberculate.

Group II. Upper jaw without either notch of cusps, otherwise as under Group I. Plastron always yellow, unblotched.

Group III. Upper jaw notched at symphisis, but without cusps. Edges of jaws not serrated. Ridge in masticating surface of jaws not tuberculate.

Group I comprises three nominal species, *P. rubiventris* LeConte, *P. alabamensis* Baur, and *P. texana* Baur. Of these the first and last are certainly distinct species, but the second, of which I have seen no specimens, may be the same as the first.

Of *P. rubiventris* I have seen only one specimen, this be-

ing a live individual from Orlando, Florida, which measured 267 mm. over curve of shell, 245 in straight line, 167 in greatest breadth, 110 in greatest height. Shell strongly arched. Carapace black with red markings, marginal plates with much red below, plastron yellowish brown, but reddish in front and behind, legs with red stripes. The head markings I couldn't see, as he would not put his head out. Lower jaw very strongly serrated, with a serrated cusp at tip; upper jaw slightly serrated, with a median notch and a strong cusp on each side of it. Date, March 16, 1902.

Alabamensis, according to Baur,* has the shell more arched than in *rubiventris*, and the plastron is yellow with brown markings, instead of red as in *rubiventris*.

Of the third species of Group I, *P. texana*, I have seen only two undoubted specimens, one a living specimen from Colmesneil, Texas, measuring 284 over curve of shell, and 265 in straight line; greatest width 215. Shell smooth, not wrinkled, and without traces of a keel. Color slaty brown with yellowish markings, the markings on the costal plates transverse to the longitudinal axis of the shell. Marginals each with a vertical yellow bar down the center. Plastron yellow without markings. Both jaws serrated, the lower much the most so; upper jaw notched in front but without cusps. Date, July 7, 1902.

The second specimen, which was from Shell Bank, La., was much the same color, and had the upper jaw notched in front, with a slight cusp on each side of the notch. Other characters, as in the first specimen. Length in straight line 225, width 150. Date, July 27, 1903.

Group II includes five nominal species, *P. concinna* LeConte, *P. mobiliensis* Holbr,† *P. floridana* LeConte, *P. hieroglyphica*,

* "Notes on the classification and taxonomy of the Testudinata, part IV, The species of the genus Pseudemys" by G. Baur. (Proc. American Philos., Soc. XXXI, May 5, 1893).

† According to Dr. Baur (*loco cito*), *P. mobiliensis* Agassiz is not the same as *P. mobiliensis* Holbr., the former being a composite species equaling *P. alabamensis* Baur plus *P. texana* Baur.

Holbr, and *P. labyrinthica* C. Dumeril, but how many species it really contains I don't know, as individual variation in at least one species seems quite wide and obliterates the distinctive features ascribed to most of the others.

According to Dr. Baur (*loco cito*) these species are characterized as follows:

Concinna by its broad and low shell and its small head.

Hieroglyphica by its elongated, narrow shell and its head, which is still smaller; the yellow stripes and dots on the head are also very much more expressed than in *concinna*.

Labyrinthica shows the coloration of head and neck of *hieroglyphica*, but the head is larger and the shell more as in *mobiliensis*, but by far not so large.

Mobiliensis has the head like *concinna*, but larger, the shell very much more arched especially in front, the animal much larger than in *concinna*, the upper shell reaching a length of 385 over the curve.

Floridanus is at once distinguished by its oval form and the great elevation of the carapace and its color. The carapace has a very dark brown color with numerous irregular lines of yellow. The marginals are dark brown and have only one vertical, median yellow line, and are without the yellow concentric lines so characteristic of *concinna* and *mobiliensis*. The carapace is much more arched than in *mobiliensis* and nearly forms a half circle. The skull is also larger than in this species and the jaws are not serrated (*sic*).

The characters quoted above, except those for *floridanus*, all fall within the range of individual variation of Raleigh specimens of *concinna*, and hence until I am able to examine specimens of the others, I cannot help feeling doubtful of their validity.

Raleigh specimens of *concinna* present the following characteristics: The carapace is marked with a variegated pattern

of brown and yellow lines, these forming more or less distinct concentric figures, parts of three of which usually enter each costal plate. Markings of the carapace usually not definitely transverse to the axis of the body, on the costals. Marginal plates marked above with a median, vertical, yellow bar, and yellow concentric figures between the yellow bars of adjoining plates; quite frequently, however, the vertical bars are absent on some of the plates and the concentric figures replaced by longitudinal yellow lines, continuous on adjoining plates, this occurring on the middle and posterior marginals, but not usually on the anterior ones. In seven adults this feature is present or absent as follows: In one the longitudinal lines replace the vertical bars and concentric lines on all the marginals; in two others they do not occur at all; in a fourth they occur only on marginals 4, 5, 6, right, and 11, 12, left; a fifth has them on the four middle marginals on each side; a sixth on numbers 5, 9, 7, right, and 6, 7, left; a seventh, on numbers 4, 7, 8, 9, 11, on both sides, and on No. 12, right also. The presence of a vertical yellow bar across the center of each marginal is so constant in all specimens of *Pseudemys* that I have seen, except those from Raleigh, that the variation seems worth noting. Head and legs with yellow stripes. Plastron yellow, unblotched.

In the shape of the shell there is also a good deal of variation, some specimens being broad and flat with a median, dorsal depression; others are broad and flat but lack the dorsal furrow, while others again have comparatively high and arched shells, and in any case the dorsal depression is only present in full grown specimens, not in young nor in half grown ones. The flat shelled specimens seem to be mainly males, and the more arched ones females, but I have not examined enough specimens to be sure that the variation is wholly sexual and not individual.

The size of the head also varies, being large in some specimens and small in others, the difference being apparently

sexual, the small headed ones being males,* the large headed ones females. Young specimens are nearly circular with a distinct dorsal keel, as in all young *Pseudemys*, but a specimen 130 mm. long has substantially the form of the adult.

Some measurements of specimens from Neuse River near Raleigh are as follows:

	Taken.				Greatest Length.	Width.	Height.
1.	Feb.	26,	1902,	sex?	131	107	55
2.	April	23,	1906,	male	150	114	54
3.	March	29,	1904,	female	161	—	—
4.	July	27,	1903,	sex?	202	139	—
5.	March	24,	1903,	male	211	150	82
6.	March	29,	1904,	female	240	158	—
7.	June	2,	1905,	sex?	240	172	80
8.	March	24,	1903,	female	275	185	110
9.	March	16,	1902,	sex?	280	195	107

Of what Baur called *mobiliensis*, I have had one adult and several smaller specimens from Baker County, in Southwest Georgia, but while the adult has an arched shell and is a little larger (290 mm. long) than the largest I have measured from Raleigh, its shell is not more arched than those of some Raleign specimens, nor is the head larger than in some of them. In coloration it is identical with Raleigh specimens, as are also the young ones, except that none of them have any vertical yellow bars and concentrix markings on the marginals replaced by longitudinal yellow lines. I am inclined to consider this form as merely, at the most, a large southern form of *concinna*.

Of *floridana* I have had three good sized adults from Johnston County, N. C., and quite a number of small and half grown specimens from Southwestern Georgia, and Florida. These differ from *concinna* in usually having a vertical yellow

* See also "Some observations on the turtles of the genus Malademmys" by O. H. Hay, (Proc. U. S. N. M., Vol. XV, No. 908) in which he states that the females of this genus have larger heads than the males.

bar, forking at the upper end, down the center of the first and second costal plates, and in having the markings on the rest of the shell less concentric and usually in larger pattern. The marginal plates have a vertical yellow bar down the center of each, with concentric markings between; these latter, however, only occur in quite small specimens, as they disappear early in life leaving only the vertical bar. Head, legs, and plastron colored as in *concinna*. Ground color of carapace dark brown, darker than in *concinna*. The really important difference lies, however, in the shape of the shell, which is shorter and more arched than in *conciuna*, being in fact more nearly the shape of that of *P. scripta*, to which species *floridana* bears a superficial resemblance. The males have smaller heads and lower shells than the females.* The upper jaw is slightly, the lower jaw strongly, serrated, in all specimens that I have seen,

The measurements of the shells of some specimens are:

	Taken.	From.	Length.	Width.	Height.
1.	June 20, 1905,	Johnston Co., N. C.,	250	197	110
2.	June 30, 1905,	" " "	222	149	95
3.	June 30, 1905,	" " "	169	—	—
4.	May 14, 1904,	Baker Co., Ga.,	136	114	57
5.	July 20, 1904,	" "	150	—	—

I have seen no specimens of *labyrinthica* or *hieroglyphica* and the characters assigned to them by Dr. Baur (*loco cito*), are not of specific value, as they fall within the range of the individual variation of *concinna*. As *labyrinthica* is smaller than *concinna* and *mobiliensis* larger, it is quite possible it is a smaller† northern race of that species, just as *mobiliensis* appears to be a larger southern race.

* According to Dr. Baur (*loco cito*) *floridana* does not have serrated jaws, qut he places it in a section of the genus with lower jaw strongly serrated, so the absence of serrations probably applies only to the upper jaw, where they are little evident.

† *Labyrinthica* occurs in Tennessee and Illinois in the tributaries of the Mississippi.

Group III comprises three species which agree in having the upper jaw with a notch at the symphisis, but without cusps on each side of the notch, in the edges of both jaws being without serrations, in the ridge in the masticating surface of the jaws being non-tuberculate, and in the plastron being more or less blotched. These three are *scripta* of the Southeastern United States, and *elegans* and *troostii* of the Mississippi Valley and southwestward.

The three may be distinguished as follows:

1. Carapace keeled at all ages, a vertical yellow bar just behind eye. *Scripta.*

   Carapace not keeled in adult, no vertical yellow bar behind eye.

2. An elongate-oval red mark on neck behind eye. *Elegans.*

   No oval red mark on neck. *Troostii.*

Scripta is a large, heavily-built terrapin, with a wrinkled shell, and a distinct dorsal keel at all ages. A diagnostic mark of this species is a vertical yellow figure just behind the eye. The marginals are marked as usual in the genus with a vertical yellow bar and concentric figures between; the latter, however, are usually absent in adults. The carapace is marked on the costals with yellow, black and brown markings, there being usually a central yellow stripe down the middle of each costal with yellow and brown lines parallel to it and meeting their fellows above its upper end, and to some extent below its lower end; the black is more irregular in amount and position than the other colors, but there is always some black on each plate in the adult, although it is wanting in young specimens. On the posterior costals the markings are less regular and more confused. The plastron is yellow, or occasionally brownish, with a round black spot on each of the two anterior plates; often there is a black spot on the next two plates also, and occasionally one on every plate,

The largest specimen I have seen weighed seven and a half pounds and measured 272 mm.

Elegans is much like *scripta* in general appearance and in markings, but the shell is flatter and not keeled in the adult and the red neck spot is characteristic at all ages. The markings on the carapace are variable, but usually much as in *scripta*, but those of the plastron are different, each plate usually containing a black or dusky spot which is usually surrounded by one or more dusky concentric lines.

Of *troostii* I have only seen one specimen and that differed greatly in many respects from all the specimens of *scripta* and *elegans* that I have seen. It was from St. Louis, Mo., and measured 185 in length and 137 in breadth, and the tip of the nose extended 107 mm. beyond the front edge of the shell, when the neck was stretched to its fullest extent. The upper jaw was notched in front, lower jaw pointed at tip, neither serrated. Both upper and lower jaws much wider and more rounded than in any other *pseudemys* with which I am acquainted, especially than in *elegans* and *scripta*, which have the snout notably pointed. Head dark above with narrow, pale stripes; chin, throat, and neck below, light colored with rather pale darker stripes on neck below, much as in *Deirochelys reticulata.* Shell rather flat on top, rounded off on sides, rather deep, and much the shape of *Deirochelys*, but the bridge and shell not so high; shell smoother and without the wrinkles so characteristic of *Deirochelys.* Carapace dark brown with indistinct paler markings, most of the marginals with faint vertical bars which are barely visible. Plastron pale with some dark markings round the edges of the plates. Superficially and in length of neck this specimen resembles a *D. reticulata* more than it does the other species of *Pseudemys*, but I found on examination that the basal portion of the ribs was short, straight and broad as in other *Pseudemys*, not long, slender and arched as in *Deirochelys.*

SPECIMENS EXAMINED.

P. rubiventris, Orlando, Florida, one.

P. texana, Colmesneil, Texas, one; Shell Bank, La., one.

P. concinna, Raleigh, N. C., nine adults and several young.

P. mobiliensis (=*P. concinna*?), Mimsville, Ga., one adult, two young.

P. floridana, Johnson County, N. C., three adults; Orange County, Fla., two young; Mimsville, Ga., two half-grown specimens and several young.

P. scripta, numerous specimens from Raleigh, N. C., and Mimsville, Ga.; Lake Ellis, N. C., several.

P. elegans, Austin, Texas, three; St. Louis, Mo., three; Shell Bank, La., one.

P. troostii, St. Louis, Mo., one

THREE LITTLE KNOWN SPECIES OF NORTH CAROLINA FUNGI.

BY J. G. HALL.

It is my purpose to take up three species of fungi that are little known in North Carolina, and in fact in the United States, and to give a brief description of them.

The first two belong to the Hyphomycetes of Saccardo, but to different groups under this head. The third belongs to the Pyrenomycetes, and the family Sphaeriaceae.

The first I have preferred to call by the known name of Martensella pectinata, although as will be seen later, there are sufficient differences to make it a new species. It was first described by Coemaus in 1863 from Belgium.

This fungus is new to North Carolina, and in so far as I have been able to determine, has not been reported in print from the United States, although I know it to be in culture in one other place than West Raleigh.

The discovery of this species was partly an accident. Last December I was making some plate cultures from some soil that came from New Bern, in the eastern part of the State, for Sclerotinia, a lettuce disease upon which we have conducted a series of experiments.

In the culture I noticed growing a fungus that at first I took to be Botrytis, but upon microscopic examination found to be Martensella.

The fruiting hyphae stood erect and unbranched, except for the short spore bearing stalks, although later I found that the fungus became branched, and some times very much so.

The erect hyphae are septate and after arising a short distance above the substratum each cell sends out a short branch near the outer end. These short branches become the sporophores, and at first are indistinguishable from the main hypha except in size. Almost immediately the tips of the sporophores bend upward at approximately right angles and the portion beyond the bend rapidly becomes closely septate, having six to nine septae. The sporophores very soon become boat-shaped with the keel toward the main hypha. Upon the side away from the main hypha there arise small protuberances, the first appearing nearest the bend, and then being produced in succession toward the tip.

These growths early begin to show a slight swelling, forming a kind of head at the tip, which later lengthens into the fusiform spores; these are constricted into a very fine thread at the base, which connects them with a swollen base (basidia) that joins them to the naviculate sporophore.

Saccardo places this fungus in that group of the Hyphomycetes called the Mucedineae, because of the looseness and lightness of color of the mycelium. Also among the Amerosporeae of the latter, because of the shape and color of the spores.

In quoting the original description in his Sylloge Fungorum Saccardo says that the sterile hyphae are procumbent, with the fertile erect, with both branched and septate; the spores are borne on short lateral branches and in two rows along the face of the naviculate sporophore, being cylindric-fusiform in shape, and measuring 10-20x3 μ; that it is parasitic on Muco and the Saprolegneae. After giving the habitat a note is added saying that Cremans describes some of the spores as being borne in chains, and Engler & Prantl reproduce figures of the fungus which show some of the sporophores bearing catenulate spores, which are nearly globose in shape.

After the note Saccardo makes the very significant remark that the appearance of the catenulate spores is exceedingly strange.

Engler & Prantl also show the sporophores with the spore-bearing surface upward and inward.

In the early part of this note I said that I believed I would be justified in making a new species on account of the differences I found between my specimens and those in Saccardo and Engler & Prantl. I found: that the plant grew very freely with Penicillium as a host; that the spores are never borne in chains but always singly; that instead of being borne in two rows along the face of the sporophore, they are arranged all over its surface. In other respects my specimens agree with the descriptions noted.

The second species that we consider is one of the Genus Epicoccum, which belongs to the Tuberculariae, another group of the Hyphomycetes, so called because the mycelium forms a tubercle or mass of threads from which the spores arise.

The spores are borne in masses almost without sporophores, but what there is of them is light brown, although the greater part of the Mycelium is white. The spores are black when mature but brownish black in the younger stages. They are rough on the surface and look very much as if they were four-celled, but I have not been able to see any definite partitions. They are globose and measure from twenty to thirty μ in diameter.

In germination the spores send out short, almost globose cells, and after forming two or three of these at each point of germination, they grow into the regular septate hyphae, which continue to lengthen for some time.

Near the growing tip of the mycelium short branches arise, at first just a single filament, but very soon becoming much and irregularly branched, forming a hemispherical mass (sporodochium) upon the surface of which the spores are borne.

As an experiment this fungus was grown upon several different kinds of media to see if different nutrients had different effects upon it.

A medium which we called C. B. A., Chemical Base Agar, was made as follows: Water, 1000 grams; Di Potassium-phosphate, 2.5 grams; Calcium Chloride, 01 gram; Magnesium sulphate, 01 gram; Sodium Chloride, 2.5 gram; Potassium sulphate, 2 grams; Agar, 15 grams.

To this was added Sodium Aspariginate in one case; Sodium Aspariginate and Starch in another; Sodium Aspariginate and glucose in another, and one or two others. Four per cent. Pea Agar and Apple-twig Agar were also used.

On the Pea Agar the Mycelium was white with very few pink spots; upon the Apple and Apple-twig Agar the Mycelium was orange yellow with abundance of pink spots. Upon C. B. A. and N. A. S. and N. A. G. the Mycelium was white but with a large number of large pink spots. In all cases spores were formed in equal abundance and they were most numerous near the point of inoculation.

The third and last species belongs to a very different group of fungi, the Pyrenomycetes, which has its spores borne in sacs (asci) within closed or nearly closed conceptacles called perithecia. In giving the systematic position of this species, I shall follow Ellis & Everhart's North American Pyrenomycetes.

This is a new species of fungus, but I hesitate to give it a name because of the scarcity of material. It is one of the Genus Podospora, in the family Sordaieae, which is one of the sub-order Sphaerioceae.

The perithecia are borne singly and scattered, are black and flask-shaped. The asci are clavate and bear the eight spores which are the distinguishing feature of the plant. They are dark, elliptical, and are joined by a filament into pairs.

So far as I have been able to learn, there is only one species that approaches this in any way, and that is Podospora zygospora, in which the spores are similarly joined in pairs, but the thread joining each pair is septate, while in this one there are no septae in the connecting thread.

VOL. XXIII NOVEMBER, 1907 NO. 3

JOURNAL

OF THE

Elisha Mitchell Scientific Society

ISSUED QUARTERLY

CHAPEL HILL, N. C., U. S. A.

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Elisha Mitchell Scientific Society

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Journal of the Elisha Mitchell Scientific Society—Quarterly. Price $2.00 per year; single numbers 50 cents. Most numbers of former volumes can be supplied. Direct all correspondence to the Editors, at University of North Carolina, Chapel Hill, N. C.

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VOL. XXIII NO. 3

PROCEEDINGS OF THE ELISHA MITCHELL SCIENTIFIC SOCIETY, JANUARY 1907 TO OCTOBER 1907.

169TH MEETING, JANUARY 15, 1907.

H. V. Wilson: The Regenerative Power of Sponges.
J. W. Gore: Direct Current Transmission of Power.
The Electrical Aging of Flour.

170TH MEETING, FEBRUARY 12, 1907.

J. H. Pratt: The Fish and Oyster Industries in North Carolina.
Collier Cobb: Some Human Habitations.

171ST MEETING, MARCH 19, 1907.

J. E. Latta: Some Recent Developments in Electric Traction.
N. C. Curtis: Architectural Composition.

172ND MEETING, APRIL 16, 1907.

Archibald Henderson: The Foundations of Geometry.
Chas. H. Herty: The Optical Rotation of Turpentines.

At the close of the program a business meeting was held to consider the programs. It was voted that a minimum of four meetings be held each year but, if possible, one meeting per month.

BUSINESS MEETING, SEPTEMBER 23, 1907.

A business meeting was held in the chemical laboratory with Pres. Herty in the chair. The following officers were elected for the ensuing year:

President: W. C. Coker.
Vice-President: J. E. Latta.
Permanent Secretary: F. P. Venable.
Recording Secretary: A. S. Wheeler.
Editorial Committee:

W. C. Coker, Chairman.
A. Henderson.
E. V. Howell.

A. S. WHEELER, Recording Secretary.

A NEW METHOD BY WHICH SPONGES MAY BE ARTIFICIALLY REARED.[1]

DR. H. V. WILSON

I have found in the course of an investigation carried on for the Bureau of Fisheries that silicious sponges when kept in confinement under proper conditions degenerate, giving rise to small masses of undifferentiated tissue which in their turn are able to grow and differentiate into perfect sponges. The investigation has been prosecuted during the past three summers at the Beaufort Laboratory. While the degeneration with the formation of the indifferent masses has been observed in several species, it is only in one species, a *Stylotella*, that the process as a whole has been worked out.

This sponge, which is exceedingly abundant in Beaufort Harbor, is a fleshy monactinellid commonly reaching a thickness and height of 10–12 cm. Conical processes with terminal oscula project upwards from the lower body. With this species, which is a light-loving form, I have obtained the best results when outside aquaria, either concrete aquaria or tubs, were used. The method of treatment is briefly this: Into a tub about 60 cm. by 30 cm. and covered with glass, a half dozen sponges, freed as far as possible from live oysters and crabs, are put. They are raised from the bottom on bricks. The tub is emptied, filled and flushed for some minutes three times in every twenty-four hours. Direct rays of the

1Published with the permission of Hon. Geo. M. Bowers, U. S. Commisioner of Fisheries.

Reprinted from SCIENCE, N. S., Vol. XXV., No. 649, Pages 912-915, June 7, 1907,

sun should be avoided. Tubs answer as well as concrete aquaria, and have the advantage of being movable.

In a day or two the oscula of the sponge disappear, and the surface begins to acquire a peculiar smooth, dense and uniform appearance. Microscopic study reveals the fact that not only the oscula, but the pores also, for the most part close, and the canal system becomes interrupted and in some degree suppressed. The mesenchyme is more uniform, and is denser than in the normal sponge, owing in part at least to the disappearance of the extensive collenchymatous (very watery mesenchyme) tracts of the latter.

The whole sponge may pass into this state and remain without great change for weeks. During this period it shrinks greatly in size, in a given case to one quarter the original bulk. The arrangement of the skeletal spicules becomes much simplified. With the shrinkage in size the sponge becomes more solid, *i. e.*, more of the canal space is suppressed. Some flagellated chambers persist and there are a few small scattered apertures on the surface. The bulk of the chambers disappear as such, the collar-cells transforming into simple polyhedral masses which become scattered singly or in groups in the general mesenchyme. The mesenchyme is a syncytium composed of well-marked cells that are freely interconnected. The sponge in this condition closely resembles *Spongilla* in its winter phase, as described by Weltner.[2] Presumably water continues to circulate through the body, but the current must be an exceedingly feeble and irregular one.

As a sponge in this condition continues to shrink, it may subdivide and thus a large sponge may eventually be represented by numerous masses, in a given case about 1 cm. in diameter. Now if the sponge in this condition or if one of the masses into which it has split up, be attached to wire gauze and suspended in a live box floating at the surface of the open water of the harbor, the sponge or piece will in a few days grow and redevelop the pores and oscula, flagellated chambers, tissue differentiation, and skeletal arrangement of

2 'Spongillidenstudien, II. Archiv fur Naturgeschichte,' 1893.

the normal sponge. Whether in this regeneration the transformed and separated collar cells again unite to form the flagellated chambers, I can not say. I think it very doubtful.

In the two classes of cases just described the sponge as a whole degenerates and slowly shrinks. Cellular death takes place so gradually that at no time is there any obvious corpse tissue or skeletal debris. Much more common and of far greater interest are the following cases. In these a large part of the sponge body dies in the course of two or three weeks, leaving the skeletal network still in place and bearing the brown decaying remnants of the flesh, which, as maceration continues, are washed away. In places, however, the sponge body does not die. Here masses of living tissue are left, conspicuous amidst the dead remains by their bright color and smooth clean surface. These living fragments may be classified into three groups. First, the upper end of an ascending lobe or a considerable part of the body of the lobe may be left alive in its entirety, thus forming a more or less cylindrical mass up to 5 mm. diameter, with a length sometimes two or three times the thickness. The histological condition of these masses is not very different from that of the sponges already described. Such a mass may be said to consist of anastomosing trabeculæ, separated by the remains of the canal system. The mesenchyme composing the trabeculæ consists of discrete cells interconnected by processes to form a syncitium. The flagellated chambers as such have nearly disappeared, although remnants may still be recognized. In them the collar cells have transformed into simple polyhedral bodies that are widely separated. The bulk of the chambers have broken up into their constituent cells, and these are now scattered as elementary parts of the general mesenchyme. When such masses are attached to wire gauze and hung in a floating live-box they transform into perfect sponges.

A second class of surviving remnants includes masses scattered over the general surface of the sponge. These may be spheroidal and small, less than one millimeter in diameter. Usually they are flattened and of an irregular shape with

lobes, suggesting a lobose rhizopod or myxomycete plasmodium. Such masses which may be connected by slender strands are commonly from two to five millimeters in the longest direction. The third class of remnants are found scattered through the body of the dead and macerated sponge, in which they sometimes occupy positions that are obviously favorable for respiration. These bodies are more or less spheroidal and small, their diameter varying commonly from one half to one and a half millimeters. In the most successful cases of treatment, the small masses, internal and superficial, are exceedingly abundant, and the dead and macerated sponge body with its contained nodules of conspicuous living tissue strongly suggests a *Spongilla* full of gemmules.

These living remnants of the sponge (bodies of the second and third classes) execute slow amœboid changes of shape and position, behaving thus like plasmodia, and they may be designated as plasmodial masses. Microscopic examination shows them to be of an exceedingly simple character, without canal spaces or flagellated chambers. The mass does not consist of discrete cells, but is an aggregation of syncytial protoplasm studded with nuclei. The protoplasm is stored with minute inclusions and is reticulate in arrangement. The nuclei are practically all alike, and there are no signs of persisting collar-cells. Such a mass represents a portion of the original sponge in which the degenerative changes have progressed farther than in the larger remnants. In the latter we find a syncytium made up of discrete cells among which some persisting collar-cells are distinguishable. But in the plasmodial mass the cells have united so intimately that cell outlines have been wiped out, and recognizable collar-cells (or their nuclei) have disappeared. The optical evidence points to the conclusion that the latter help to form the general syncytium, undergoing regressive changes in their differentiation which result in their becoming indifferent parts of this unspecialized tissue.

The plasmodial masses remain alive in the laboratory indefinitely, but do not transform. They attach to the bottom

of the vessel, but so feebly as to be easily shaken loose. In order to see if they would transform when returned to natural conditions, I devised the simple plan of enclosing them in fine bolting-cloth bags which were hung in a live-box floating in the harbor. The bags, rectangular, were divided into compartments about an inch square with the two flat sides nearly touching. In each space an isolated plasmodial mass was inserted, and the bag sewed up. It was found that in such bags the masses were held in place long enough for them firmly to attach to the bolting cloth. Once attached to the cloth they grow, sometimes quite through the wall of the bag to the outer water, and transform into perfect sponges with osculum, canals, pores and flagellated chambers in such abundance as to be crowded.

This ability to undergo—when the environment is unfavorable but not excessively so, regressive changes of differentiation resulting in the production of a simpler, more uniform tissue, is something that is plainly useful, *i. e.*, adaptive. In the simplified state the sponge protoplasm withstands conditions fatal to such parts of the body as do not succeed in passing into this state, and on the return of normal conditions again develops the characteristic structure and habits of the species. That this power is exercised in nature there can scarcely be a doubt, since the conditions that are present in an aquarium must now and then occur in tidepools.

It is probable that the power thus to degenerate with the production of masses of regenerative tissue is general among sponges. I first discovered the phenomenon in *Microciona*, a very different form from *Stylotella* and one in which the skeleton includes much horny matter. And in two other Beaufort species I have succeeded in producing the plasmodial masses. There is every reason for believing that the commercial sponge shares in this ability. If this is so, we have here a means of propagation which with a further development of methods may at some time become economically practicable. In any case it is now possible to study the differentiation of a quite unspecialized tissue, one that is physi-

ologically embryonic, into a perfect sponge at any time of the year irrespective of the breeding season. We may even exercise some direct control over the size of the plasmodial masses, as the following experiment shows.

Microciona was kept in aquaria until the degenerative process had begun. Pieces were then teased with needles in a watch glass of sea water in such a way as to liberate quantities of cells and small irregular cell-agglomerates. These were gently forced with pipette to the center of the watch glass. Fusion of cells and masses, with amœboid phenomena, began at once, and in half an hour quite large irregular masses existed. In the course of a few hours the masses grew enormously through continued fusion. From this time on they adhered firmly to the glass, retaining irregular plasmodium-like shapes, and the growth was inconspicuous. To bring them together once more and induce further fusion they were on the following day forcibly freed, with pipette and needle, and to clean them of cellular débris and bacteria were transferred to a tumbler (covering with bolting cloth) in which they were kept actively moving under a fine glass faucet for about thirty minutes. In the course of this violent agitation a good many masses were lost. Those remaining in the tumbler became in the next few hours noticeably rounder and smoother at the surface. From this experiment eighteen more or less spheroidal masses were obtained, some of which measured one half millimeter in diameter. They were similar to the small plasmodial masses produced in this species (and in *Stolotella*) when the sponges are allowed to remain quietly in aquaria. As already stated, it is only in *Stylotella* that I have directly proved the regenerative power of these masses.

Maas has just announced[3] that calcareous sponges (*Sycons*) when exposed to sea water deprived of its calcium undergo

3 'Ueber die Einwirkung karbonatfreier und kalkfreier Salzlösungen auf erwachsene Kalkschwämme und auf Entwicklungsstadien derselben. Archiv fur Entwicklungsmechanik der Organismen,' Bd. XXII., Heft 4, December, 1906.

marked degenerative changes, which may be of such a character that the living tissue quite separates from the skeleton and breaks up into compact cords of cells showing active amœboid phenomena. The cords further constrict into rounded masses the likeness of which to gemmules is pointed out. Maas states that he is not yet in a position to say whether these masses have the power to transform into sponges, but adds that some of his observations induce him to believe that this is possible.

It is evident that Maas, working on very different forms, has independently met with the same degenerative-regenerative phenomena as are described in this communication, the essential facts of which were presented (together with an exhibit of gemmule-like degeneration masses and young sponges into which such masses had transformed) at the recent December meeting of the American Society of Zoologists. I may add that more than two years ago at the end of the summer of 1904, in my official report (unpublished since the research was still in progress) to the Bureau of Fisheries on the investigation under my charge, I described the degenerative phenomena in *Microciona* and *Stylotella*, *i. e.*, the formation under certain conditions of confinement of minute masses presenting a likeness to gemules, and emphasized the probability that these masses were able to regenerate the sponge. It was not, however, until the summer of 1906 that I was able to demonstrate the truth of this view.

UNIVERSITY OF NORTH CAROLINA.
CHAPEL HILL, N. C.,
February 16, 1907.

THE CONDENSATION OF CHLORAL WITH PRIMARY AROMATIC AMINES. II.*

BY ALVIN S. WHEELER.

A number of condensation products of chloral with primary aromatic amines have already been described. The first mention of such a reaction is probably that of Maumené[1] who hoped to obtain indigotine by the action of chloral (2 mols.) upon aniline (3 mols.). His product was a brownish black uncrystallizable substance containing no chlorine. Schiff and Amato[2] first describe a condensation product of chloral (1 mol.) and aniline (2 mols.) with the formula

$$CCl_3CH(NHC_6H_5)_2.$$

In the same year Wallach[3] describes this compound. Later[4] he gives a full description of the products obtained from aniline, p-toluidine, and a sample of xylidine boiling at 212°-216°. Eibner[5] studied the condensation of chloral with p-nitraniline, m-chloraniline, p-chloraniline, and 1, 2, 4-dichloraniline and showed that 1, 2, 4, 6-trichloraniline and 2, 6-di-

*Contribution from the Chemical Laboratory of the University of North Carolina.

1[Ber. 3. 246, (1870)].

2[Gazz. chim. ital. 1,376 (1871)].

3(Ber. 4. 668).

4(Ann. 173,274).

5(Ann. 302,235).

chlor-4-nitraniline do not react. Wheeler and Weller[6] prepared the o- and m-nitraniline compounds and Wheeler and Daniels[7] showed that only addition products could be obtained with the naphthylamines. Niementowski and Orzechowski[8] found that one molecule of chloral condensed with one molecule of anthranilic acid but later[9] obtained the expected diphenamine compound. Finally Rügheimer[10] describes the compounds with o- and p-phenylenediamine and 1, 2, 4- and 1, 3, 4-toluylenediamine. He also states that only addition products are obtained with the naphthylamines.

The chloral diphenamine compounds vary considerably in stability. Most of them may be kept for years. They possess great crystallizing power. Their behavior toward alkalies is variable. The aniline derivative is decomposed by alcoholic potash into aniline, chloroform and phenyl cyanide according to Wallach. The p-nitraniline derivative is converted by alcoholic potash into an hydroxy compound, one chlorine being replaced by the hydroxyl group according to Wheeler and Glenn[1]. They are not stable in the presence of strong mineral acids. These split the compound so as to reform the amine. Eibner has shown that boiling acetic anhydride and benzoyl chloride give the acetyl or benzoyl derivative of the original amine. I have found that all of them react with great readiness with bromine in the cold. There is a substitution of one hydrogen atom in those which have been analyzed. This substitution probably occurs in the methylene group of the chloral residue.

With the exception of the anathranilic acid products the following are thought to be new.

6(Jr. Am. Chem. Soc. 24, 1063).

7[Jr. Elisha Mitchell Sci. Soc. 22, 90 (1906).

8(Ber. 28, 2812).

9(Ber. 35, 3898).

10(Ber. 39, 1653).

1(Jr. Elisha Mitchell Sci. Soc. 19, 63, 1903).

CHLORAL AND p-BROMANILINE.

Trichlorethylidenedi-p-bromphenamine,

$$CCl_3CH(NHBrC_6H_4)_2.$$

With C. W. Miller. Ten grams of p-bromaniline were dissolved in 50cc benzene and 8 grams of chloral (4.2 grams required by theory) in 10cc benzene were added. The mixture was concentrated one-half on the water bath and cooled. A white flocculent precipitate came down. This gave a melting point of 135°. On further evaporation a second crop was obtained, showing a melting point of 119°. By several recrystallizations from benzene the melting point was raised to 140°. The yield of the crude product was quantitative.

Analysis:

0.1588g substance gave 0.2049g CO_2 and 0.0352g H_2O.
0.1638g substance gave 9cc nitrogen at 15° and 755mm.
0.0890 substance heated with 0.3274g $AgNO_3$ required 9.8cc NH_4SCN (1cc = 0.0173g $AgNO_3$).

	Calculated for $C_{14}H_{11}N_2Cl_3Br_2$	Found
Carbon	35.45	35.03
Hydrogen	2.34	2.46
Nitrogen	5.93	6.38
Chlorine + bromine	56.24	55.58

Trichlorethylidenedi-p-bromphenamine consists of fine colorless needles, melting at 140° and decomposing at 205°. It is extremely soluble in alcohol, acetone, glacial acetic acid and hot benzene. It is sparingly soluble in cold benzene and insoluble in ligroin. It is readily purified by using a mixture of benzene and ligroin. It is not decomposed by boiling water but is split by boiling concentrated hydrochloric acid with the regeneration of p-bromaniline. A bromo derivative is easily obtained by adding bromine to a glacial acetic acid solution. The product, consisting of plates, melts at 203°

after several recrystallizations from glacial acetic acid. Determinations of carbon, hydrogen and nitrogen give very satisfactory figures for a monobrom compound. A study of its constitution is under way. Chlorine gives a similar reaction. The product, crystallizing in long colorless needles, melts at 93° after recrystallization from glacial acetic acid. Analysis indicates a monochlor derivative. These bodies will be described in a later paper.

CHLORAL AND o-ANISIDINE.

Trichlorethylidenedi-o-methoxyphenamine,

$$CCl_3CH(NHOCH_3C_6H_4)_2.$$

With W. S. Dickson. Two molecules (12.3g) of o-anisidine were dissolved in 50cc benzene and one molecule (7.3g) of chloral were added. After warming a short time on the steam bath a separation of colorless needles occurred. These decomposed at about 215° and weighed 0.05g. On concentration of the filtrate in a dessicator a mass of fern-like crystals was obtained mixed with a thick liquid. After filtering the crystals were pressed on a porous tile. The product was white, melted at 112°-114° and weighed 9.7 grams. On recrystallizing from benzene the melting point was raised to 121°. The thick liquid finally solidified, considerably increasing the yield.

Analysis:

0.2000 gram substance gave 0.2294 gram AgCl.

1.0000 gram substance gave 0.073 gram nitrogen (Kjeldahl).

	Calculated for $C_{16}H_{17}O_2N_2Cl_3$	Found
Cl	28.35	28.35
N	7.47	7.30

Trichlorethylidenedi-o-methoxyphenamine crystallizes from ligroin or benzene in magnificent rhombohedra, from one

quarter to one half inch long, always with a slight yellow color. It is easily soluble in cold benzene and carbon tetrachloride and hot glacial acetic acid. It is slightly soluble in cold ligroin and fairly soluble in hot ligroin. It crystallizes from alcohol in long slender prisms. One hundred cubic centimeters of boiling alcohol will dissolve approximately 7 grams and at 25° about 2.5 grams. It is insoluble in and unchanged by boiling water. When boiled in concentrated hydrochloric acid the odor of chloral could be detected in the vapors. A bromo derivative is readily obtained by adding bromine to a concentrated glacial acetic acid solution. The crystals occur in clusters of needles and decompose at about 230°. This compound is being further investigated.

CHLORAL AND p-ANISIDINE.

Trichlorethylidenedi-p-methoxyphenamine,

$$CCl_3CH(NHOCH_3C_6H_4)_2.$$

To a solution of 12.3 grams p-anisidine in 20cc benzene (a nearly saturated solution) is added 7.3 grams chloral. The solution turns to a dark red color at once, much heat is developed and a deposition of 0.22 gram small colorless crystals occurs. These decompose at about 215° as in the case with o-anisidine. After filtering, the reaction mixture is boiled 15 minutes and then allowed to stand several hours. An abundant crystalline precipitate is formed. After filtering and pressing on a clay plate, the product melted at 115° and weighed 10.5 grams. A further yield was obtained from the mother liquor. Purification was effected by using the mixed solvent, benzene and ligroin. The melting point was raised to 118°-120°.

Analysis:

0.2087 gram substance gave 0.2398 gram AgCl.

	Calculated for $C_{16}H_{17}O_2N_2Cl_3$	Found
Cl	25.35	28.41

The para compound crystallizes from ligroin in brilliant scales, showing a strong pink color in the mass. It melts at 118°-120° and decomposes at 158°. It is fairly soluble in cold benzene, alcohol and ether. It is readily soluble in glacial acetic acid, hot benzene and hot alcohol. The hot alcohol solution emits a most disagreeable odor and on spontaneous evaporation to dryness a jet black crystalline mass remains. It is very slightly soluble in cold ligroin and not readily in hot ligroin. On treatment with bromine in glacial acetic acid solution a crystalline product is obtained which blackens at about 198°. This compound will be studied further.

CHLORAL AND ANTHRANILIC ACID.

The product obtained in this case depends upon the proportions used. One molecule of chloral will condense with one or two molecules of anthranilic acid with the elimination of one molecule of water. The two products have been described by Niementowski but his method yields a mixture and we have improved upon it since we wish to make the compounds in quantity in order to study their bromo derivatives.

Trichlorethylidene-o-aminobenzoic Acid,

$$CCl_3CHNC_6H_4COOH.$$

With W. S. Dickson. Five grams of anthranilic acid were dissolved in 40cc boiling benzene (a saturated solution) and 5.5 grams chloral in 10cc benzene were added. The weights are in the proportion of one molecule to one molecule. The mixture was boiled under a reflux condenser for three hours, filtered from a small precipitate and then cooled. A crystalline deposit, weighing 5.0 grams and melting at 148°-151°, separated. The crystals were large elongated tables, occurring in clusters. From the filtrate was obtained 3.0 grams of material, melting at 145°-150°. Several recrystallizations from benzene raised the melting point to 152°. Niementow-

ski and Orzechowski[1] prepare this compound without the use of any solvent. They use an excess of chloral and get several by-products. We have tried their method but have employed theoretical proportions. Even so we get the same by-products. We set the mortar in a block of ice and rapidly stirred together the previously cooled substances. The mixture liquefied and then rapidly became very hard. This product decomposed at about 127°, after two hours on ice at 124° and after three hours more at room temperature at 118°. It was rubbed up with a little water and filtered. The decomposition point rose to 135°. Now taking advantage of the marked difference in solubility in benzene of the mono- and di-compounds (not observed by Niementowski) we extracted the crystalline mass, weighing 8.2 grams, with 45cc boiling benzene. From the extract there separated a mass of colorless needles, weighing 3.7 grams and melting 149°-152°, hence nearly pure mono-compound. On evaporating the filtrate a residue was obtained, weighing 1.3 grams and melting at 160°, a good quality of the di-compound. A second extraction was made with 33cc of boiling benzene. On cooling this yielded a product weighing 0.8 gram and melting at 162°, and a residue at 157°. There still remained an insoluble residue, dark purple in color. These results are in marked contrast to those obtained by our method of boiling in benzene, for we get practically only the mono-compound and consequently a much larger yield.

Analysis:

0.2000 gram substance gave 0.3189 gram AgCl.

	Calculated for $C_9H_6O_2NCl_3$	Found
Cl	39.92	39.43

On treating a glacial acetic acid solution of this compound with bromine a bromo derivative is obtained in large quantity. On cooling a hot glacial acetic acid solution it deposits

1(Ber. 28, 2812).

in clusters of fern-like crystals which decompose at 237°. This body is under investigation.

Trichlorethylidenedi-o-aminobenzoic Acid,

$$CCl_3CH(NHC_6H_4COOH)_2.$$

Five grams (2 molecules) anthranilic acid in 40cc boiling benzene were treated with 2.9 grams (1 molecule) chloral in 10cc benzene and boiled under a reflux condenser for three hours. During the boiling there separated 3.25 grams of the di-compound, melting at 164°-165°. On cooling a further yield of 0.6 gram was obtained. On evaporation to dryness the residue was found to weigh 4.0 grams and to melt at 157°. The pure body melts at 165°. The method of Niementowski[1] was tried and although found to be better than for the preparation of the mono-compound it gave a smaller yield than our method and a larger amount of unknown colored by-products.

Analysis:

0.5000 gram substance gave 0.0410 gram NH_3 (Kjeldahl).
0.2000 gram substance gave 0.2113 gram AgCl.

	Calculated for $C_{16}H_{13}O_4N_2Cl_3$	Found
N	6.96	6.76
Cl	26.11	26.10

The di-compound consists of a crystalline powder and may be purified by precipitating its ether solution with ligroin. Upon boiling eight hours with acetic anhydride and cooling, a crystalline substance deposits, melting at 183° and crystallizing from benzene in needles. This corresponds to acetyl-o-aminobenzoic acid. On treating a glacial acetic acid solution with bromine there is almost instantly obtained a heavy precipitate which after recrystallization from glacial acetic acid melts with decomposition at 236°. This behavior is surprisingly like that of the bromo derivative of the mono-anthranilic acid compound.

[1](Ber. 35, 3898).

CHLORAL AND o-TOLUIDINE

Trichlorethylidenedi-o-tolamine,

$$CCl_3CH(NHC_6H_4CH_3)_2.$$

With Strowd Jordan. Chloral and o-toluidine were brought directly together in the proportion of one molecule to two molecules. No advantage was found in using benzene as a solvent. 19.3 grams chloral were added to 28 grams of o-toluidine, the mixture turned dark red and the temperature rose to 80°. After standing for some time, often over night, a quite hard crystalline cake formed. This was dissolved up in ether or successively extracted with benzene. In either case, a small residue weighing 0.7 gram remained. This was pale greenish in color and melted at 213°. The main product of the reaction was recrystallized from ether until the melting point reached 80°.

The yield was 70 per cent of the theory.

Analysis:

0.1763 gram substance gave 0.2194 gram AgCl.
0.2000 gram substance required 0.2915 gram $AgNO_3$.
0.2000 gram substance required 0.2973 gram $AgNO_3$.

	Calculated for $C_{16}H_{17}N_2Cl_3$	Found		
Cl	30.95	30.77	30.40	30.96.

The Stepanow method[1] was employed in the second and third analyses and found to be extremely convenient. With some of our compounds we have found it impracticable on account of the deep color of the solution. We found it advisable to adopt the suggestion of Rosanoff and Hill[2] and filter off the silver chloride before titrating.

Trichlorethylidenedi-o-tolamine crystallizes in very long silky needles. It is not very stable in solution or when ex-

[1](Ber. 39. 4056).

[2](Jr. Am. Chem. Soc., 29, 269).

posed to the light. It is decomposed by water into chloral and o-toluidine. It is soluble in cold alcohol, ether, acetone, chloroform, carbon tetrachloride, carbon disulphide and glacial acetic acid. It is soluble in hot ligroin, benzene and methyl alcohol. The pure substance melts at 80° and will melt repeatedly at that temperature. A bromo derivative is readily obtained in glacial acetic acid solution. It forms silvery white plates which melt with decomposition in the neighborhood of 268°.

PHYSIOLOGICAL ACTION.

We were led to a study of the physiological action of the trichlorethylidenedi-o-tolamine by an accidental observation. Mr. Jordan unintentionally got a small quantity in his mouth and within a few hours there followed a marked physiological action. A preliminary test has been made upon two rabbits. Dr. William DeB. MacNider of this University kindly carried out the test for us in the pharmacological laboratory of the University of Chicago. A 5 per cent dilute alcoholic solution was employed. This was first used in 10cc doses, intravenously. It produced at first a slow heart action accompanied by a slight fall in blood pressure. Following this initial change the respirations became accelerated, the heart action fast and the fall in blood pressure much more pronounced. Doses of 25cc given by the stomach caused the animal to become drowsy, inactive and imperfectly responsive to stimuli. The respirations were accelerated. One rabbit returned to a normal condition in six hours. The other animal, receiving the drug by the stomach, died apparently from respiratory failure. A more complete study is under way upon a large number of rabbits. This study will be extended to other diphenamine derivatives of chloral.

Chapel Hill, N. C.
Oct. 16. 1907.

RECENT CHANGES IN GOLD MINING IN NORTH CAROLINA THAT HAVE FAVORABLY AFFECTED THIS INDUSTRY

BY JOSEPH HYDE PRATT AND A. A. STEEL *

Before taking up an account of the changes that have been recently introduced in gold mining in North Carolina, it may be of interest to mention some of the causes for failure in the profitable mining of gold in this State, as the changes to be described hav to some extent at least modified and lessened the chances for failure.

Many of the causes of failure in North Carolina gold mining can be traced to a lack of adequate capital, which prevents mining from being conducted in the most economic manner. One of the most noticeable of these is the tendency to sink the shafts but 15 to 30 feet before driving a new level and then stoping out a small block of ground instead of having the levels from 75 to 100 feet apart. Since a ton of ore removed in driving the level even in a wide vein will cost fully twice as much as a ton of ore in stoping, it is obviously more economical to have as few levels as possible. It it becomes dificult to make the raises more than 100 feet and is expensive to get men and timbers into much higher stopes. Therefore, the levels should not be over 100 feet apart. In a narrow vein where much waste could be left in a stope, the economy is greater. Somewhat similar to this is the habit of sinking a number of shafts close together instead of only one or two on a vein. This is not so bad for working ore

* Published with the permission of the State Geologist of North Carolina

near the surface, but becomes very expensive as the mine gets deeper, especially when hoisting machinery is required on each shaft. This is partially explained by the fact that many of the old mines have been worked at very irregular intervals and the old shafts have become caved in during the period of idleness.

Even those mines having capital are often badly managed. They frequently put in machinery of unnecessarily large capacity, not realizing that a very small engine and bucket can easily get out 10 or 15 tons of ore per day and keep a five stamp mill busy. There are many little mines that could pay a profit under careful management with five stamps and running only one shift; but some of them have engines big enough to hoist four times as much ore. Since the engineer and top men must be there all the time, there is no economy in operation but may even be a loss, since the engine cannot work steadily and fuel is wasted keeping up a big fire; and' of course, the first cost is greater. If the mine ever gets much too big for the small engine, it can be used in prospecting or underground work.

A great many shafts are much to big. It is not uncommon to see a little bucket, 30 inches accross dangling in the middle of a hoisting compartment 6 feet square in the clear, It is considerably cheaper to sink a shaft with compartments only 4 feet square in the clear and when the hoisting compartment is smoothly lined with plank (to assist ventilation), or fitted with guides, it has jnst as great a capacity — usually more than enough for the output of the mine. If necessary, the hoisting capacity of a shaft may be greatly increased at any time by putting in a tall bucket, or better a self-dumping skip and high speed engine. The ladder and pipe compartment is often as big as 6 by 8 feet. Since the cheaper and better direct acting steam pump would now be placed in a shaft, instead of the clumsy and bulky Cornish pump, the water, steam and compressed air pipes take up very little room. It is now customary to put in slanting ladders between landings some distance apart. They can almost as well be a little

steeper and shorter and go in a smaller space. The men will always ride up in a bucket, fitted with a crosshead running in proper guides or running in a closely planked compartment if the shaft is crooked. Therefore, the ladderway is an emergency exit only and a good, continuous vertical ladder securely fastened against one wall of the compartment is all that is needed, and the compartment for ladder and pipes may seldom need be over 3 by 4 feet. The two compartments and the division between them then need be only 4 by8 or 3½ by 7 feet inside. Besides being much more cheaply and rapidly sunk, the small shaft need not be so heavily timbered, since the shorter timbers are stronger and the earth pressure tends to arch around the shaft instead of coming fnll upon the timbers. On the other hand, the first 6 by 10 feet (8½ by 12½ feet outside timbers) shaft at the Montgomery Mine, at Candor, Montgomery County, became useless after about 5 years from the buckling of the timbers, although splendidly timbered with 12 by 12 inch oak sets, which showed no signs of decay.

There is, of course, very seldom any need for more than one hoisting compartment, since the saving in power will only pay for the greater expense of engine and shaft when a large amount of ore is to be hoisted from considerable depth. When a single large skip will handle all the ore, there is no need of putting in another to remain idle half the time.

Timber framing for shafts and tuunel sets is often unnecessarily complicated and the carpenter must waste mnch time chiselling, when simple notches laid off with a square and cut by saws are often stronger and always more easily made.

The most disastrous error is usually great haste in putting in a mill or smelter. It seems that the first thing that many miners think of after finding a little good ore is to stop work in the mine and put in a mill; so there are mills which have been able to run less then a month before the mine was exhausted. There is usually a neighboring mill to which the ore might as well have been hauled. It is seldom that tests are made to tell what sort of a mill and treatment is adapted

to the ore. Unless the ore body is large, no mill should be installed until the changed ore below the water level has been tested.

In North Carolina there seem to be only a few miners who deceive themselves by assaying the rich streak and assuming that the entire streak will be equally as good. The general principles of sampling the entire body seem to be well understood, although it is not always done as accurately as it should be.

Even when good ore occurs in paying quantities the miner frequently builds a mill that is too large; For there is only a little extra expense in increasing the size of the mill after it has been running awhile instead of building a large mill all at once. So there is little excuse for assuming the greater risk of a large mill. There is less loss of gold in adjusting a small mill.

One agreeable exception to the practice of building a mill before the mine is sufficienty developed is seen in the work of the Whitney Company, who have carefully tested and explored a number of mines. Many of the options were given up of course. At the old McMakin Mine at Gold Hill, as explorations proved the value of the mine, the contemplated scale of working was gradually increased. When the small shafts of the upper levels were deepened, the lower parts were made large enough for balanced hoisting and the small part will be enlarged later. In the meantime most careful sampling and assaying was done and when enough ore had been blockedout, careful mill tests were made chiefly upon the material obtained from drifts. In this way a total of 4,950 tons of ore was run through the little mill on the ground; careful records of everything gave an average recovery of \$4.52 of gold on the plates and only \$0.34 per ton as a concentrate worth but \$5.03 per ton and \$0.83 per ton in the tailings. These tests made clear that the most economical method is simple amalgamation, giving a saving of about 80 per cent of the gold, with no attempt to concentrate and treat the concentrates.

The two main shafts are down 800 feet and another is 400 feet deep, with the levels averaging over 700 feet long. This work shows a vein averaging 14 feet wide and gives a million and a half tons of ore blocked out ready to stope, and which will yield $2.50 per ton by amalgamation. They have accordingly planned a mill large enough to treat 1,000 tons of ore per day, making the estimated total cost of mining, milling and transporting the ore only $1.48 per ton. They are now waiting for the completion of their water-power plant before building the mill and since they have sufficient ore blocked out, the mine has been idle and full of water since the spring of 1905. The intention is to keep a reserve of 500,000 tons of ore in advance of the stoping.

The Bonnie Doone, or Old Smart Mine, has also been properly developed by Mr. J. C. Bates, a former owner of the Howie Mine. The old 80 foot shaft has been deepened to 200 feet, with levels 125 feet long at 60 feet, 100 feet at 120 feet, 160 feet at 186 feet. The ore obtained from these workings is now piled in a large dump estimated to contain 3,000 tons. And before the mill was planned, this was carefully sampled by a competent mining engineer, who dug deep trenches across it and found it to average $15.00 per ton. Of course a great deal of the same quality of ore has been blocked out in the mine. There are about 500 tons in another dump of material which came from work in the walls and is chiefly slate but contains a few of the veinlets and masses of milky quartz, and is said to assay about $1.50 per ton. It has been kept out of the good ore at only a nominal expense. The mill has not been built on account of the continued sickness of the owner, so there is no machinery at the mine except the sufficiently large prospecting hoist.

As an example of a mill too large for the development may be mentioned the Reimer Mine, near Salisbury. Here a 20 stamp mill with chlorination failed simply because no ore at all had been blocked out and it could not be mined rapidly enough to keep the mill going. An examination of the mine by the late Mr. Parker, mining engineer for the Whitney

Company, showed a remarkably continuous vein, averaging 3½ feet wide and carrying $7.50 in gold.

Mr. Parker planned to develop the mine so that it might easily yield 50 tons per day, so the total cost of mining and treating the ore would be about $4.50 per ton, which includes depreciation, etc.

The general custom of having no reserves of ore blocked out prevents conservative mining men from investing in them, since there is no way of determining the value of the vein unless it is opened up. It would be much better to spend the cost of a premature mill in developing ore so that there would be no difficulty in securing capital or selling the mine to advantage.

It is also quite customary to extract all of the ore by underhand stoping. This becomes very expensive when the vein is so narrow that some of the wall-rock must be broken to make room, or when the vein contains much barren rock. All of this waste material must then be hoisted to the surface and much of it becomes mixed with the ore in the bins and chutes. If the stopes are mined upward or overhand, all the waste can be left in them supported on a single line of stulls over the drift. This often affords a scaffold for the men and so saves the great expense of putting in many stulls. In addition a large block of filling will serve as a pillar to hold the walls apart so no ore need be left in the mine. One excellent mine superintendent said that the reason for this was the fact that most of the miners are more properly farmers and cannot drill holes upwards. They do not work steadily enough to warrant an attempt to teach them how, even though skilled men prefer to drill "uppers." This objection can be overcome in those mines having air drills for driving levels by installing a few of the blockholing or air hammer drills which may be held in one hand and, besides being much quicker, can be worked in stopes too narrow for hammering by hand. So far there seems to be none of these machines in North Carolina, although they are becoming standard in the west.

When the mines yield rich ore in narrow streaks, it should be hand-picked before going to the mill. For this purpose the Miami Mining Company have installed at the Phoenix Mine, near Concord, Cabarrus County, an ore picker. The ore is sorted into coarse and medium material by passing through a trommel, where it is also washed by a spray pipe. It then passes over a couple of belts 30 inches wide and 30 feet long. A number of boys sit along these belts and pick out the waste, which is removed by another belt, while the good ore passes direct to a Dodge crusher. The dirt and fine ore removed by the water is raised by a sand pump directly to the battery. These machines would not pay at a small mine where an arrangement like that at the Hercules Mine at Cid, Davidson County, is better. Here the ore is dumped from the skip on to a slightly elevated platform, where it is washed by a stream of water from a hose and the waste thrown into a car standing near, as the good ore is shovelled into a car for taking it to the mill.

Since the publication of Bulletins Nos. 3 and 10 of the North Carolina Geological Survey, there have been a number of changes in mining practiced in the State, which, given in the order of their probable importance, are:

1. The application of machines of the old log washer type to separate gold from saprolites as is now being practiced at the Shuford, Empire, Beaver Dam, Troy, Sawyer and other mines.

2. The introduction of square set timbering in the extraction of soft, deep ore bodies, which is now being practiced at the Union Copper Mine at Gold Hill.

3. The introduction of the cyanide process for treating certain sulphuret ores, which has been practiced on the tailings trom the Iola, Montgomery and Howie mines.

4. The introduction of self-dumping skips, picking belts etc.

LOG WASHERS

Perhaps the most important change to be noted in gold mining practice in North Carolina is the introduction of log washers in treating many of the saprolitic ores that are found quite abundantly throughout many portions of the State. The old principle of the log washer cannot be patented, but the machines that are now being used, known as modern pulverizing concentrating machines, possess many mechanical improvements that adapted them to the work that they are called upon to do.

Each separate unit of these machines consists of two improved log washers running at high enough speed to readily disintegrate the soft material and so mix the clay into a fine pulp with water that the gold can readily settle to the bottom. Each machine is essentially a long trough or boiler plate containing a revolving cylinder fitted with heavy white iron arms set spirally so that the ore, while being hammered fine, is gradually worked to the discharge end. At the end of the first washer, the larger, hard and nearly barren quartz stones are removed by a revolving screen and belt conveyor, this being done to save wear and power in the second washer, where the gravel is still further reduced iu size and more gold settles out. The gravel that remains after passing the second washer is removed by a finer screen and the chief pulp, free from stones, passes from the riffled sluices about three feet wide and of varying lengths, which contains mercury to amalgamate and save any free gold that does not settle in the machine.

The steel troughs are about 2 feet wide by 2½ feet deep, the first being 18 feet long and the second 12 feet, with a semicircular bottom and a flat wood top. The revolving cylinder is made of an 8-inch steam pipe carried upon a heavy steel shaft, passing through stuffing-boxes at the ends of the trough. Wrought iron bars reach through this pipe crosswise and project about 3 inches on each side to form legs to which 8½ inch cast iron arms are bolted to take all the wear. There is about 4 inch clearance between these arms and the

bottom of the troughs, which allows the formation of a bed of stones, which reduces the wear on the bottom and helps save the gold. This bed of stones is of course more or less shaken up by blows from the large fragments of quartz and by the revolving arms, thus permitting the gold to settle through as in panning. The constant striking of the paddles against the surface of the water will also weight and sink some of the float gold. The discharge end of the machine is set 6 inches higher than the feed end so that the gold, once down amongst the pebbles of the bed, is not apt to be pushed out.

Riffles of the sluices are made by boring inclined auger holes in the planks laid lengthwise in the cement-lined sluice boxes. Since all the coarse gravel has been screened out, there is little wear upon the riffles and the fall and quantity of water are less than in the regular sluice for hydraulic mining. In cleaning up, the planks are lifted up and turned over and the gravel and mercury washed to the end of the sluice where quicksilver and amalgam are washed out in hand pans. When through cleaning up, the planks are simply replaced and the riffles filled with mercury and the machine started again.

In cleaning the washers, which is usually done twice a week the machines are stopped and all the gravel within washed out with a hose through an opening in the bottom. This gravel is then panned by hand and the gold amalgamated. Any nuggets that occur in the rock are pounded free from quartz and are then also amalgamated.

The amalgam from all sources is strained out of the quicksilver and then retorted and the bullion sold.

The chief wear on the machine is the arms, which under certain conditions, as on the sharp ore at the Shuford mine, only last six weeks. They can, however, be readily made at any foundry.

It is recommended by the maker that the first washer be driven at 150 to 250 revolutions per minute and that the second one at 250 to 350 per minute and that for a capacity of 10 tons

per hour, each machine be given 72 gallons of water per minute. This will then at times require 25 H P. for a complete unit of two washers and trommels. These factors will vary greatly with the character of the ore. Since the power, and therefore the wear, will increase even more rapidly than the square of the speed, this should be kept low. In the absence of any coarse stones, there is also danger that the pulp may be too greatly agitated to allow the settling of the gold. On the other hand, the speed and work must be sufficient to grind up the ore. If there is too little water, the clay paste may not allow the gold to settle. If there is too much, there is a danger of the gold being washed out. While a large capacity is of advantage and desirable, still it will mean danger of insufficient grinding, too thick pulping, or too strong a flowing of water. A great deal of skill and patience is, therefore, required in adjusting these fixtures, but when once adjusted, they will work satisfactorily. It is to be recommended that a first unit be installed and run over several months at various speeds, capacities and amounts of water and the machine should be given plenty of time after each change of condition to adjust itself. Also, careful tests of the ore and tailings should be made between times. The capacity and speed should first be adjusted until the best result is given in reducing the amount of gold left in the tailings so combined that it will not pan. The pulp should of course be kept at a reasonable consistency throughout the changes and the amount of water finally adjusted so that the tailings will show a minimum of free gold in the pan.

These machines are made in Knoxville, Tenn., and are handled by Geo. L. Erdman, of Asheville, N. C. One of the first of these machines was installed at the Shuford Mine, owned by the Catawba Gold Mining Company, and situated about three-quarters of a mile north of the post-office of Edith, about 5 miles south-east of Catawba Station on the Southern Railway. They have a plant of 4 double units. The Company are operating on a tract of land containing a gold-bearing zone said to be 2 miles long and 600 feet wide.

This will all pan gold at the surface and has been tested by bored holes 30 to 50 feet deep to water level and by one old shaft 115 feet deep. This zone is filled with small quartz seams from a line to occasionally several inches thick and having all possible strikes and dips and seldom more than two feet apart in every direction. The country rock varies from schist to gneiss and is generally heavily stained by iron oxide and thoroughly decomposed, except for a few, bold outcropping hard masses. The quartz is usually thoroughly honey-combed and broken into soft, angular fragments. Except at the surface, most of the gold is in these quartz streaks, but the hard and solid portions of them seldom have much value. At the present time the entire mass is being mined by means of an irregular pit which was, in the summer of 1906, 90 feet deep and 250 to 300 feet across at the top. The material at the bottom is just as soft and decomposed as at the top and the ore is loosed by black powder and shovelled by hand into cars containing a cubic yard. The cars are hoisted up a steep incline and automatically dumped over a grizzly of light steel rails. The fines are washed through the grizzly by jets of water, the soft large lumps being crushed and knocked through by means of a pick. In 18 months operation only a few tons of large, hard lumps have thus far been thrown out. The material is then washed down a trough about 50 feet long, thus becoming pretty uniformly mixed before being divided among the washers. At this mine the machines are run at only 150 revolutions per minute. They were tried at a lower speed, but there was trouble with the gold sticking to clay balls. The machine used about 150 gallons of water to the minute and the whole plant is run by a 35 horsepower engine which, when the three units are running, is probably overloaded. The tailings, when tested, usually pan nothing at all, but assay a few cents, due to gold included in the sand. While this loss could be reduced by speeding up the second washer to grind the sand finer and trusting to the riffles to save what little additional free gold would not then settle in the machine, it

is doubtful whether with the present small plant and so vast a quantity of ore controlled by the Company such refinements are advisable, since they would probably reduce the capacity of the plant. It is estimated that the present cost of treatment is 22 cents per cubic yard loose measure with a recovery of between 50 cents and $1.00 per cubic yard.

A great deal of the success of the Catawba Gold Mining Company is due to its conservative policy and the skill with which the whole mining and milling operation has been conducted.

The next machine to be placed in operation was at the old Laflin Mine, near Cox, Randolph County, about 4 miles east of Cid Station on the Thompsonville and Glen Anna Railway. The Empire Mining Company own a tract of land which contains argillaceous slates containing two gold-bearing zones, 200 feet wide by ½ mile long, the northwest zone being along the south side of a hard quartz and siliceous slate vein. The early work on this property was done at the northeast end of the northwest zone where there are several large pits, some 50 feet deep. The entire surface was tested by pan assays (weighing the amount of gold from known weighed amounts of ore) and a number of trenches were dug across the better portions of the zone. The results of this test led the Company to instal their experimental plant on the gentle slope to another stream near the southwest end of the northwest zone. At the other end the slates are still soft at a depth of 50 feet, but here they were found to be quite solid and tough within 6 or 7 feet of the surface, though drill holes are said to have proved that the rock is again soft below a 5 or 6 foot shell of hard material. The dip at this end is only 15 or 20 degrees instead of being nearly vertical as at the other. This tough slate is thoroughly oxidized and shows a very uniform distribution of wheat-like grains of limonite, formed from pyrite, which lie along the cleavage planes of the slate and all the gold occurs in them.

This small branch has a steep fall for 2 miles to the Yadkin River and for the experimental plant water is returned

from a small settling pond nearby. In order to get sufficient fall for the head and tail sluices, the machines are put pretty high up on the hill so that a fat incline has been put in with dumping arrangements, etc. similarly as at the Shuford Mine. The ore is broken up by hand into about 3 inch cubes and when not hard, there is some tendency for it to stick in the grizzly crusher owing to the large percentage of clay, which is often moist. The first machine is run as high as 250 revolutions per minute on hard rock, but was found to give best results on average partly decomposed slates at 175 revolutions per minute. As there is no hard quartz in this ore, there is no need of an intermediate trommel. The second machine is operated at only 90 revolutions per minute and saves most of the gold, which is very fine. The trommel which follows this washer removes practically nothing but fragments of tree roots, which shows that everything is ground below 4-mesh. The riffles are 64 feet long, but very little gold is found below the first 20 feet. With this soft, clayey ore the capacity is about 8 tons per hour and 110 gallons of water per minute are required. In the summer of 1906 the machine had hardly passed the experimental stage, but the tailings almost never showed any free gold and assays of carefully taken samples showed a recovery of 90 per cent of the soft material and 80 per cent on the hard.

A few modifications of the machine have been made by Mr. O. K. McCutcheon, Superintendent of the Empire Company, by introducing an improved stuffing box and valve for the clean-up openings and in the second washer iustalling a plate 9 inches wide and one inch above the center of the bottom with cross-lots ½ inch by 5 inches. This false bottom is curled up at the discharge end and serves as a riffle plate, thus considerably increasing the recovery of very fine gold.

One double unit of these machines was being worked on the property of the Troy Mining Co., 7 miles north of Troy, Montgomery County. There are some old shafts, but the two main workings are based upon recent discoveries. By test pits and panning it seems there are two parallel zones of

slate bearing gold. Open cut No. 1 shows white and pink, clay-like slates with iron stains and abundant limonite cubes and seams. The direction of the slates is N. 45° E. and part of the material seems to represent thoroughly decomposed, sheeted, coarse grained porphyry so that the deposit is probably on a contact. The values are not uniform and at a depth of about 12 ft. the deposit seems to be about 20 ft. wide, 50 ft. long and the upper part of a rounded lens, richest in the center, where a 25 ft. shaft is said to have produced $30.00 ore. To develop deeper, a shaft was sunk in the hanging wall. At a depth of 70 feet, it was stopped just as it began to cut light-colored, sericitic schists, carrying pyrite.

The material from open cut No. 1 was all conveyed by a sluice to the mill, a short distance away. Although a good deal of gold was saved, the tailings ran $3.00 a ton and tests were stopped.

Open cut No. 2 was made by recent unsuccessful hydraulic mining. It was, at the time of the visit, 200 feet long, 20 to 24 feet wide and 2 to 10 feet deep. This zone pans quite uniformly 18 to 20 feet wide in the cut and in cross trenches beyond the end of it. No assays of average samples have been made. There is a barren, white quartz vein, with some large quartz crystals, along part of one side of the zone and most of the material seems to have been more or less siliceous sericite schist, now thoroughly decomposed to purple clay or fine sand. At the time of the visit, 100 tons were being hauled over muddy roads to the mill about a quarter of a mile away, to make a test run.

The machines were found to give a little less free gold in the tailings as the speed was reduced, and at the time of the visit, both sections were being run at only 60 R.P.M. The rate of feeding is very low, apparently only 2 tons per hour, and the amount of water is very large, apparently about 150 gallons per minute. As there was no hard pebbles or other material in the ore to form a bed in the machine, it is probable that most of the gold was washed out. Even at this low rate of speed the coarsest tailings were very fine

particles of sand. Samples of the tailings included only the coarser, rapidly settling parts, so that the assays made were probably too high. It may be that the slower speed simply decreases the pan assay of the tailings by not freeing such a large percentage of gold which remains included in the larger grains.

The most apparent recommendation would be to put McCutcheon riffles in the bottom of the machine, run the first machine faster than the second and greatly increase the percentage of ore fed to machine as compared with the amount of water used. No samples of the ore had been taken so the tests are not conclusive.

The latest reports are that the tailings from open cut No. 2 also assayed $3.00 to $4.00 per ton; that the washers are abandoned and that a 50 ton cyanide mill will be erected. It is also said that some good ore was struck below a quartz vein in a 17 ft. shaft, sunk in open cut No. 2. It is probably well to abandon the washers here because the thoroughly decomposed soil gets very hard not far from the surface, and the water level will be less than 30 feet below the highest part of the ore zone now exposed. Therefore the available tonnage of decomposed material is rather small. A shaft on a third vein, just below the creek bed, shows hard silicified sericite slates, with much pyrites but no visible copper or other minerals which would interfere with the cyanide plant adapted for handling slimes.

Machines have also been installed at the old Sawyer Mine in Randolph County 5 miles west of Sophia and about 14 miles from High Point. This property has been worked off and on for many years, but has failed because the gold could not be saved by a stamp mill and plates. The machine will first treat the soil and very soft outcrops and then the hard rock, which does not slack by itself will be crushed fine by rolls and the machine used simply as a panning device. This will be a new and novel use for this machine and the results will be watched with interest.

The McCutcheon modification of the Modern Pulverizing and Concentrating machine is being installed at the old Mer-

rill Mine on Carraway Creek 3 miles west of Sophia. The old workings are said to show a zone 1-2 mile long which is composed principally of clay to a depth of 50 or 60 feet. There are eight long cross-cut trenches and many test pits have been made which are said to have given ore running from $1.50 to $1.90 per ton.

Near Newton, Catawba County, one of the machines is being installed to work a property said to be similar to the Shuford Mine in the same county.

From information obtained by observation in the field and tests in the laboratory, it would seem that this Modern Pulverizing and Concentrating machine is adapted for certain ores such as those of the Shuford Mine and that with certain modifications as have been worked out by Mr. McCutcheon, the machine can be adapted to still other ores. It is necessary, however, to make a careful study of the ore and to adjust the machine to each particular ore before it can be determined whether or not the machine will save the gold; and a machine should not be accepted or discarded until the ore has been thoroughly tested to ascertain whether or not the machine can be adapted to that particular ore.

SQUARE SETS.

The second change in mining practice of great importance to the gold mining industry in North Carolina is the introduction of square set timbering in the extraction of soft deep ore bodies. This method was introduced by Mr. H. L. Griswold, superintendent of the Union Copper Company's mine at Gold Hill, N. C. In former mining the old stopes were held open by miscellaneous timbering such as stulls, lock sets and truss sets. Such methods were not satisfactory and prevented the stoping of the ore in the most economical manner. By the introduction of the western square set method of timbering, the stoping of the ore is being done safely, completely and economically. The sets are made of 8 x 8 inch sawed oak and the mine carpenter can usually easily frame enough timber for this work in about one-eighth of his time. The

sets are 6 ft. 3 inches high in the clear and 5 feet across in the clear. The posts are, therefore, 6 ft. 3 inches long between the shoulders and have a 5 x 5 inch tenon 1½ inches long at each end; the caps are 5 ft. 3 inches between shoulders and have a 5x5 inch tenon 2½ inches long at each end; the ties are 5 feet between shoulders and have a tenon 5x8 inches and 1½ inches long at each end.

The size of the timbers will of course vary with the weight to be sustained. This style and proportions of framing are very good for oak timbers; but for pine, which crushes so easily across the grain, it is better to have the ends of the post tenons to touch each other. The light timbers are of course cheaper and much more easily handled. As the stopes get large, they are more or less completely filled with waste rock which is usually obtained in mining and would otherwise have to be hoisted out in working the usually underhand stopes. This filling also holds the posts in position and helps to prevent them from buckling or "jack-knifing" if any one timber yields, which might otherwise endanger the whole system. Since most of the pressure is downward, as soon as the ore is blasted away to make room for a new set, all the sets below are relieved and tend to come back to their original position. Thus, even light timbers will hold very well if the stope is worked rapidly enough.

In the Union Copper mine the square sets were founded upon a platform built upon the old solid looking truss sets. As soon as a heavy load came upon them the trusses buckled sidewise and everything caved in. A new foundation was then made upon reinforced stulls and there has been no trouble since. Mr. Griswold is starting a new lot of square sets in a large open chamber just above the fourth level and he will thus be able to work out easily all the ore left above, especially a big pillar that remains between the first and second levels.

A new set can be added in any position at any time without disturbing the adjoining timbers and the old timbers can easily be supported by temporary props while making room

for an additional set. When the old timbers have been replaced the entire flooring of sets is easily put in as the ore is removed; a temporary plank covering may be placed across the old timbers to protect the men from falling rocks. Temporary plank floors are placed upon the sets for the men to stand upon and, as the system becomes higher, chutes and mill holes are put in to conduct the ore to the car on the track below. Any waste rock mined is merely dumped in and around the lower sets.

There has been little or no trouble indtroducing the square set method of timbering and at the Union Copper Mine the work is done under the immediate supervision of Mr. Hedrick, a skilfull North Carolina shift boss who has had no previous experience with square sets. Some of the miners, especially negroes, when first stoping by means of square set timbering are a little nervous because they are so close to the roof that they can see how loose the rocks are; but they soon realize that they can pick down the loose rock or prop it up and, therefore, are safer than when they are so far away that they cannot tell at what moment the rock may fall upon them. Also when working at the bottom of a high, underhand stope, a blow from even a small rock would be dangerous.

CYANIDE PLANTS.

The introduction of the cyanide process for treating certain sulphuret ores is a third change in mining practice in the State that has added considerable to the production of gold. One of the most successful cyanide plants was the one erected to work the tailings of the Howie mine, near Waxhaw, Union County. This mine is in a zone of hard, siliceous slates, carrying chimney-like bodies of pretty high grade ore. The gold is all free but so finely disseminated that the high grade ore which is a laminated or schistose quartz has merely a golden sheen. A great deal of this escaped amalgamation although enough was saved to pay well. These old tailings, which are rumored to have been worth 5 or 6 dollars a ton, soften

somewhat upon exposure to the weather so that the recovery by cyanide was very good.

The old cyanide plant had four iron tanks 5½ feet deep and 30 feet in diameter and supposedly the necessary other tanks and apparatus. When the tailings were exhausted the mine was sold to the Colossus Mining Company, a London corporation, which proposed to put in an immense plant to treat the entire zone. This zone had previously been cross cut by two trenches somewhat over 20 feet deep, but it was never properly sampled, for although there are many fairly rich streaks, the general average value is only 40 to 50 cents a ton. The tanks of the old mill were made a part of the new big mill, so the original arrangement of this successful plant could not be learned and also no one could be found to give information about the successful treatment. There is now a Ledgerwood cableway for economical handling of excavated rock. This dumps the skips of rock upon the feeding platform of a very large gyratory crusher discharging into a trommel. The coarse rock from the trommel goes through a smaller gyratory crusher into the bin cotaining the finer rock. From this bin it is hoisted to a long, rotating cylinder dryer discharging to the first of a pair of Allis rolls working in series with necessary screens and elevators. The fine material from these rolls is divided among three ball mills of peculiar design. They have a vertical axis bearing arms which push a number of six inch iron balls around a horizontal runway.

There are at present no screens on these, and the product contains a good deal of troublesome dust or slimes, and some sand too coarse for successful cyaniding. From the ball mills a fine set of conveyors carry the dry material to any one of the leaching tanks. There are six tanks 5½ feet deep and 40 feet in diameter, and four tanks 5½ feet deep by 30 feet in diameter, all in the open air; and the necessary solution, gold and slump tanks. The mill is very badly designed since the rolls have scarcely capacity for 75 tons per day and the ball mills were so overworked that much coarse sand passed

through them. On the other hand, the crushers, elevators, etc., have a capacity fully four times as great. The mill has been used by the present management in making cyanide tests upon the rich ore remaining in the chimneys. Even when crushed very fine this fresh unaltered ore can be leached for a week without apparently giving up more than half its gold, thus this cyanide plant cannot be used for this ore.

At present the most productive cyanide plant in this State is the one at the Iola Mine, near Candor, Montgomery County. The ore, coming from a pretty sharply defined vein, is either a hard, glassy, white quartz with traces of unreplaced slate, carrying coarse gold in octahedral crystals; or soft sugary, white quartz generally richer but not showing visible gold. This "sugar quartz" has lately been running from $14.00 to $20.00 per ton. It is crushed in a dilapidated 20 stamp mill where the coarse gold and much of the fine gold is amalgamated as usual. The tailings are elevated and are run to the various settling tanks or "sand boats," 3 feet wide at one end, 5 feet at the other, 12 feet long and 3½ feet deep, having at the small end a wooden lattice on the inner side of which a canvass curtain may be rolled up from the bottom. When the thin tailings run into this the sand settles out and the fine part or slimes flow into the slime tanks. As the sand accumulates the curtain is unrolled so that the overflow is just above the level of the top of the sand. The other two sand boats, just above the tanks, are plain boxes 6 feet by 3½ by 15 feet. One end is bored full of holes to let out the slimes. These are plugged as the level of the sand reaches them.

The wet sand from these boats is shovelled or wheeled into whichever of the sand tanks may be empty. This shovelling thoroughly breaks up any water tight layers of slime which may have formed when the mill was shut down for a short time, and the thin pulp remaining below the overflow has a chance to settle in a layer on top of the sand. It also supplies the needed oxygen to aid the cyanide in dissolving the gold.. The sand tanks were made locally of yellow pine and

are 4 feet deep and 20 feet in diameter with the usual cocoa matting filter in the bottom. When filled to convenient height, they hold 40 tons of sand. A solution containing 1.4 pounds of potassium cyanide per ton of water is pumped upon this and drained off through the filter; this solution is kept circulating as rapidly as possible, keeping the sand always covered, for three or four days until the sand must be removed to make room for another batch. Then the solution is allowed to drain off, after which a little water is added to displace what solution remains in the damp sand. The sand is then washed out by a stream of water from a hose through an opening in the bottom of the tank into a trough or launder, to a settling pond where the sand settles out and the water collects to be pumped back again.

The slimes flow from the sand boats to one of the three agitation tanks 10 feet deep and 20 feet in diameter. Near the bottom of each of these is a slowly revolving paddle consisting of four well braced oak arms carrying pins. Some of the surplus water is drained off and a solution carrying 1 pound of potassium cyanide per ton of water (0.05%) is added. The agitation continues while the solution and slimes are drawn off at the bottom to a 4-inch centrifugal pump, thus thoroughly aerating and mixing it. This process continues until the tank is needed for more slimes. The solution is then pumped into one of the settling tanks 14x18 feet at a little lower level. Here the solid matter slowly settles out and the clear solution is drawn off. Sometimes the slimes are returned for a treatment with a second solution until they are finally sluiced out to waste. The solution from the sand tank, which now contains the gold, is passed directly to the zinc boxes; these have six compartments, 2x2x2 feet, with a side trough and a diaphragm for circulating the solution. This arrangement allows any one box to be emptied and cleaned while the solution circulates through the others.

From the zinc boxes the solution flows to the sump tank, 10x20 feet. Here more potassium cyanide is added to replace what has been consumed until the solution reaches the right

strength. This sump tank thus serves for a solution tank, from which the solution is raised by a small centrifugal pump to the sand leaching tanks. Most other mills have a small extra tank at the highest level in which the solution is made up and from which it flows by gravity to the sand tanks.

The clear solution from the slime settling tank is stored in the tank 24x8 feet. From this it flows through an eight compartment zinc box like the other one and to the sump and weak solution tank.

In the zinc boxes zinc from a mass of fine zinc shavings enters the solution in place of the gold which is precipitated as a black coating upon the zinc. Each month the zinc in the boxes is sifted and the fine stuff saved, and the coarse stuff returned to the box. The deficiency of coarse zinc in the first box is made up by taking some of it from the second, which is in turn filled from the third and so on. All the fresh zinc required is added to the last compartment, and, since much of the gold sticks to the zinc until it is all dissolved, most of the gold slimes are recovered from the first compartment where precipitation is also most active, as the solution passing through it contains the largest percentage of gold.

The gold slimes, or finely divided gold, containing small scraps of zinc, is melted in a graphite crucible to which a little nitre is added to oxidize the zinc and cause it to unite with the borax used as a flux. The melted gold is cast into bricks and sent to the mint.

All the tanks are in the open air. The pipes are wrapped to prevent freezing, and there is no trouble except that heavy rains increase the amount of solution which must be wasted and so cause a greater loss of potassium cyanide. The pumps, and the engine for driving them and the agitators, are housed in. In the same building is the room containing the zinc boxes and furnace for melting the bullion. About 4-10 of a pound of potassium cyanide is consumed per ton of ore. In the ore are no copper minerals or similar substances to consume cyanide.

Eight pounds of lime are added to each ton of tailings on its way to the cyanide plant. This is to cause the slimes to settle more readily and neutralize any acid which may be formed from the pyrites in the ore, and which would otherwise consume cyanide. The chief loss of cyanide is, therefore, in the solution that is wasted with the wet slimes.

There is required one solution man at $1.50 a day for each shift. If one-half of the steam used at the mill is charged to the cyanide part, the total cost exclusive of interest and depreciation is $0.90 per ton. The tailings from the cyanide plant contain about $1.00 per ton of gold. Since the sands from the mill had been carrying $4.86 per ton, there is a handsome profit in the cyanide plant—about $2.90 per ton treated. The cost of the plant was from $10,000 to $12,000. The loss in the tailings could be reduced by a longer treatment of the sands and the intention is to add two more sand leaching tanks for this purpose.*

At the Montgomery mine, which adjoins the Iola, there is another cyanide plant for treating tailings from a 10 stamp mill. All of the tanks are square. The stream of tailings is first separated into slimes and sands in a pointed box. Near the bottom of this box is a pipe out of which the coarse sand, which settles most rapidly, flows to the settling tanks, over the sand tank, while the slimes overflow at the top opposite the inlet. The slimes are not treated and the sand treatment does not differ essentially from that at Iola. The mine was shut down at the time of the visit so no data as to the cyanide treatment could be obtained. From the relatively greater tank capacity, the sand probably receives a longer treatment. The solution tanks and zinc boxes are inside the mill.

There is a new cyanide mill at the Southern Homestake Mine, 13 miles south of Thomasville, near Cox, Randolph County.

*NOTE—The data as to the cyanide treatment was mostly obtained from Mr. W. T. Sawyer, former superintendent, checked as far as possible by Mr. Jones, the present superintendent.

The ore passes over a grizzly, the oversize from which goes through a Blake crusher, and, with the fines from the grizzly, are elevated to a trommel screen above a small storage bin. The oversize from this trommel passes through a pair of corrugated rolls, then back to the same trommel, and so on, until it is all reduced to sand. The corrugated rolls chattered badly on account of the coarse feed; and the soft clayey ore tends to stick them so it will probably be better to use instead a number of smooth rolls in series.

The fine dry ore is taken by a belt conveyor to one of the three sheet iron leaching tanks, 6 feet deep and 30 feet in diameter. It was assumed that the solution would percolate through the 5½ feet of dry crushed ore, even though the slimes were not removed; but in the actual tests the tanks were filled only half full. Below the level of these leaching tanks are zinc boxes and sump tanks; the three solution tanks are on a trestle outside the main building, covering the leaching tanks.

The property was purchased without adequate sampling and the work was abandoned after treating 150 tons and finding that the ore averaged only $2.00 a ton. No data as to time of treatment, strength of solution, etc., was obtained. The recovery on the three tanks tried was 70, 80 and 83 per cent respectively. The ore is decomposed rock, occurring in wide zones and carrying a great deal of clay. No data was obtained as to the capacity of the mill.

MINING DETAILS (SELF-DUMPING SKIPS, ETC.)

Many of the mines in North Carolina are based upon more or less flat veins and since most of the ore is hoisted in buckets, it is customary to sink vertical shafts. When the mines become deep, this requires expensive cross-cuts to reach the vein; hence there are many vertical shafts which are turned upon reaching the vein and not adapted to the use of a cage or an ordinary style skip. Mr. Geo. E. Price has overcome this difficulty at the Rudisill Mine, at Charlotte, Mecklenburg County, by modifying the ordinary skip, and

adapting it to his special needs. The shaft is vertical for 200 feet and then inclines at an angle of 35° from the horizontal for 150 feet more. The skip is the ordinary iron skip, except that the wheels are a little larger than usual to reduce friction on the incline and all have narrow treads. In the vertical part these wheels run between two vertical guide timbers. The rope is not over the center of the shaft but toward the dumping side so that when the skip reaches the top the front wheels run down the forward curve of the track until they strike the top. Then the rear wheels swing to the rear in the arc of a circle. Just before they reach the top of this arc the nose of the skip strikes a roller which raises the front wheels sufficiently to bring them to a bearing against the front vertical guide so that in case of overwinding the skip rises at the dumping angle and rock cannot be dumped down the shaft. In this way the skip need wait at the top of the shaft only long enough for the ore to slide out of it, which is but a small fraction of a minute.

The ore is dumped from the car on to a platform about 3 feet below the level of the rails and the skip is stopped with its top about level with this platform and nearly filling the opening in it. If the output of the mine was a little greater, Mr. Price would replace the platform by a small bin, into which the cars could be dumped as they reach the station and from which the ore could be rapidly run into a skip through a chute. But since the man that would be required to operate the gate has ample time to shovel all the ore into the skip, there would be no labor saving in the bins and no justification for the expense. For even a small mine this skip saves the labor of a top man.

In the ordinary vertical shaft the bales of the skips are fitted with shoes and there are no wheels on the skip which is unlatched and dumped at the top by rollers striking suitable curved guides. Such a skip has the advantage of needing only one set of guides and no wheels, but it cannot be operated around a curve.

The labor of the top man is also avoided by a self-dumping bucket observed at the Haile Gold Mine, South Carolina. This is an ordinary bucket fitted with guide wheels. The back wheels are caught by a latch at the dumping place and turns over when the rope is slacked off. Then the bucket is raised, the latch is withdrawn by the engineer and the bucket lowered.

CHAPEL HILL FERNS AND THEIR ALLIES

The accompanying list of ferns of this region, including an area of about two miles radius around Chapel Hill, has been in course of preparation for several years, and is now, in all probability, very nearly complete. The topography of Chapel Hill is quite favorable to fern growth, and the number found here is as large as could be expected in regions free from limestone.

In his "Catalogue of the Indigenous and Naturalized Plants of the State," by Dr. M. A. Curtis*, there are given thirty-eight true ferns and eleven fern allies for the State of North Carolina. Of the species mentioned by him, eighteen ferns and four fern allies occur in Chapel Hill, while two of the ferns in the following list are not recorded by Curtis for this State. These are Botrychium obliquum var. dissectum, and Dryopteris Goldieana var. celsa.

The list of our ferns is as follows:

BOTRYCHIUM OBLIQUUM MUHL. (B. ternatum Chapm.). Ternate Grape fern. Not uncommon in damp, shaded places.

BOTRYCHIUM OBLIQUUM VAR. DISSECTUM. Dissected Grape-fern. Found only once in a low place near Judge's spring.

BOTRYCHIUM VIRGINIANUM (L.) SW. Virginia Grape-fern. Rather more common than B. obliquum and occurring in similar situations.

OSMUNDA SPECTABILIS WILLD. Royal Fern. (Distinct from O. regalis L. of Europe). Common along small streams.

OSMUNDA CINNAMOMEA L. Cinnamon Fern. Common along small streams and in low, damp places.

POLYPODIUM VULGARE L. Common Polypody. Very rare. Known only to occur at Upper Laurel Hill where it covers the face of a high rock, looking north.

*Geological and Natural History Survey of North Carolina, Part III, Raleigh, 1867.

POLYPODIUM POLYPODIOIDES (L.) A. S. Hitchcock. (P. incanum Sw.). Resurrection Fern. On shaded trunks of elms and occasionally on rocks; not rare.

PTERIDIUM AQUILINUM (L.) Kuhn. (Pteris aquilina L.) Bracken or Brake. In dry woods and sometimes in fields. Common.

ADIANTUM PEDATUM L. Maiden-hair Fern. Found in three situations; in rich places near the foot of hills looking north.

CHEILANTHES LANOSA (Michx.) Watt. (C. vestita Sw.) Hairy Lip-fern. Found only on one rock on northern side of Morgan's Creek near Scott's Hole.

ASPLENIUM PLATYNEURON (L.) Oaks. (A. ebeneum Ait.) Ebony Spleenwort. Common in woods and in niches of stone walls.

ASPLENIUM ACROSTICHOIDES Sw. Silvery Spleenwort. Found only in two clumps near the base of Lone Pine Hill looking north.

ASPLENIUM FELIX-FOEMINA (L.) Bernh. Lady Fern. Very common along streams and in damp places.

WOODWARDIA AREOLATA (L.) Moore. Chain Fern. Found only in a marshy spot about one-half mile south-west of the University.

ONOCLEA SENSIBILIS L. Sensitive Fern. Scattered here and there in wet places.

DRYOPTERIS ACROSTICHOIDES (Michx.) Kuntze. Christmas Fern. Abundant along streams and on northern slopes of hills.

DRYOPTERIS THELYTERIS (L.) A. Gray. Marsh Shield-fern. Found only in marsh north of Lone Pine Hill.

DRYOPTERIS GOLDIEANA (Hook.) A. Gray. var. celsa. This fern was recently found near the northern foot of Lone Pine Hill. About eight specimens occurred scattered over a radius of seventy-five yards. It has not before been recorded for this State. It was described from Dismal Swamp by Palmer in the Proceedings of the Biological Society of Washington, Volume XIII, page 65, 1899. Specimens have since

been found in New York and New Jersey. For this information I am indebted to Professor L. M. Underwood and Mr. R. C. Benedict of New York. Dr. Underwood considers the fern a hybrid between D. goldieana and D. marginalis. It is not described in any of our manuals.

PHEGOPTERIS HEXAGONOPTERA (Michx.) Fée. Beech Fern. Not uncommon in flat places along small streams.

WOODSIA OBTUSA (Spreng) Torr. Found only on a few stone walls in town.

The fern allies found here are as follows:

EQUISETUM HYEMALE L. Scouring-rush. Found by Dr. H. V. Wilson along Morgan's Creek. Occurring also along the Oxford road near Durham.

LYCOPODIUM ALOPECUROIDES L. Club-moss. Growing only in an open wet place near the spot where Woodwardia was found.

LYCOPODIUM COMPLANATUM L. Christmas-green. Found by me only near upper Laurel Hill. Reported from a few places by others.

SELAGINELLA APUS L. Spring. Rather common among moss in wet places.

W. C. Coker

SALISBURY'S PHYSIOGRAPHY.*

COLLIER COBB.

Teachers of physiography in colleges will welcome this book, not only because it is the first of its kind of college grade, but also for the large amount of fresh material that it contains and its admirable arrangement, the author being at the same time a skilled investigator and a successful teacher.

"In the preparation of the text," he tells us, "the effort has been to shape it, when practicable, so as to lead the student into the subject under discussion, rather than to tell him the conclusions which have been reached by those who have made the subject their special study." The author holds persistently to that idea of physiography which regards the origin of land forms as its chief problem. This is not the English idea of physiography, but it is preëminently the American idea. It is the geography which Mackinder of Oxford defined as the study of the present in the light of the past, as distinguished from geology, which is the study of the past in the light of the present.

If the high school teacher is disappointed that small space has been given to certain topics that he has associated with text-books of physical geography, such as minerals and rocks, and plants and animals, let him remember that in colleges, where the author purposes the book shall be used, special courses in these related subjects are given in associated departments. In fact a strong point of the book is that,

*PHYSIOGRAPHY. By Prof. R. D. Salisbury, University of Chicago. 8 vo. 770 pp. American Science Series—Advanced Course. $3.50. New York: Henry Holt and Company.

with the exception of a few references to physiographic effects on human life, scattered through its pages, it presents physiography as a science associating causes and effects clearly and forcibly, thus avoiding the mistake made by many who exalt physiographic control at the expense of a science deeply interesting for its own sake.

Any study of the origin of land forms involves the study of both air and water, since air is the medium through which solar energy is applied to the earth, and water is the greatest agent in producing effects on the earth's surface. Though the greater part of the book is given to land forms, still 273 pages remain for the treatment of the atmosphere, the ocean, and the earth's solar relations. The treatment is essentially dynamic, and the movement in the direction of the explanation of the origin of the land forms of the earth. The reader is led to see these forms in the process of becoming what they are, and to anticipate the time when they shall give way to other forms. The surface of the earth becomes a stage where physical forces play their part, now in one role, now in another, until the land above the sea is reduced to base level, or rejuvenated by elevation to begin a similar sequence of events, to enter upon a new cycle.

The first chapter of the book introduces the reader to the chief relief forms of the earth's crust and the materials out of which they are made. This general survey places the problem of the land forms well before the student, and prepares him for the consideration of the agents that have shaped them. Then follow chapters explaining and discussing the work of the atmosphere, of ground water, running water, snow and ice, of waves and currents in the construction of shore forms, of vulcanism, and the effects of crustal movement, or diastrophism. For the first time does the work of the atmosphere receive anything like adequate treatment in a text-book of physiography. These chapters are followed by a very excellent generalization and summary of the origin and distribution of land forms clinching in the minds of the students the facts that have been brought out and driven home by varied investigations.

The part played by the atmosphere in the evolution of surface forms has received a treatment comparable in detail to that presented by special text-books of meteorology. The energy derived from the sun is followed through a series of transformations, in the chapters on atmospheric pressure, the movement of air currents, and the transportation of water vapor to its final precipitation upon the earth. The various elements of climate and the zones of climate receive due attention. In these chapters the composition of the atmosphere, the air in its life relations, the distribution of temperatures over the earth, and the philosophy of the movements of the air are treated in an interesting and original manner. The chapter on the storms of the United States is especially detailed and illustrated by a complete series of isothermal charts and weather maps. Following the chapters on the atmosphere, six chapters covering fifty pages are given to the discussion of the principal facts of oceanography.

The book contains more than seven hundred illustrations, forty-three of which are sections of topographic maps; and of the others more than half are half-tones from excellent photographs. This can by no means replace field-work but serves rather to invite to work out of doors; for the author says in his preface: "Another phase of work which should not be neglected is work out of doors. This must form a part of the work of every strong course in this subject. Directions for local field-work cannot be outlined profitably in a text-book, for the work must be shaped with reference to the specific locality where the subject is studied. Both field-work and map work should have for their aim the application of the principles studied, in such a way as to make the subject vital. The aim of every laboratory exercise carried out in connection with this subject should be the same, and any laboratory work which does not either illustrate and enforce principles, or lead to them, is not worth development. The student who cannot apply what he has learned in the class-room to to his out-of-door surroundings, has not secured the maximum good from his study of the subject."

At the end of each chapter is a well selected list of topographic maps, with suggestions as to their use in relation to the text, and a list of classified and paged references for supplementary reading. These references, even without the text, would be a most valuable aid to the advanced student or teacher, as they have been gathered through long experience in the class room. The author's style is pleasing and not too technical, and the average public school teacher will find the book an invaluable aid in the teaching of physical geography, though it was written primarily for the college student.

VOL. XXIII DECEMBER, 1907 NO. 4

JOURNAL

OF THE

Elisha Mitchell Scientific Society

ISSUED QUARTERLY

CHAPEL HILL, N. C., U. S. A.

TO BE ENTERED AT THE POSTOFFICE AS SECOND CLASS MATTER

Elisha Mitchell Scientific Society

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Journal of the Elisha Mitchell Scientific Society—Quarterly. Price $2.00 per year; single numbers 50 cents. Most numbers of former volumes can be supplied. Direct all correspondence to the Editors, at University of North Carolina, Chapel Hill, N. C.

JOURNAL

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ARTIFICIAL KEY TO THE SPECIES OF SNAKES AND LIZARDS WHICH ARE FOUND IN NORTH CAROLINA.

1. Eyelids moveable; external ear present; underparts covered with numerous scales; limbs present, except in Ophisaurus. *Lizards.* 2.
   Eyelids immovable; no external ears; underparts covered with broad band like plates; limbs absent. *Snakes.* 7.

2. Limbs absent. Length when adult about 2 ft. of which about two thirds are normally tail. **Glass or Joint Snake.* (*Ophisaurus ventralis*).
   Limbs present. Length when adult 1 ft. or less. 3.

3. Body very smooth and shiny. 4.
   Body not very smooth and shiny, scales at least somewhat rough. 5.

4. Length about 5 inches or less, unstriped. *Ground Lizard* (*Leiolepisma laterale*).
   Length over 5 inches or else with lengthwise stripes. Large adults often unstriped with reddish head. *Blue-*

*The tail as in all lizards is very easy to break off, and hence a glass snake with an injured tail growing afresh, may have the tail quite short.

tailed Lizard, "*Red-headed Scorpion*" (*Eumeces quinquelineatus.*)

5. Back crossbanded, or else throat and sides of belly dark blue. Scales very rough. *Fence Lizard* (*Sceloporus undulatus*).
Back not crossbanded, throat not dark blue, scales not very rough. 6.

6. Back with lengthwise stripes *Sand Swift* (*Cnemidophorus sexlineatus*).
Back unstriped. Color green, brown or blackish. *Green Lizard*, "*Chameleon*" (*Anolis carolinensis*).

7. A pit of hollow in the side of head between eye and nostril. Plates on underside of tail mostly not in pairs. Head much broader than the neck. *The Rattlesnakes and their kin.* (*Family Crotalidae*). 8.
No pit on side of head between eye and nostril. Plates on under side of tail in pairs. Top of head covered with large plates. 11.

8. Tail with a rattle. Top of head covered with large plates. Size small. Rattle small. *Ground Rattlesnake* (*Sistrurus miliarius*).
Tail with a rattle. Top of head covered with small scales. Size large, rattle large. 9.
Tail without a rattle. Top of head covered with large plates. 10.

9. Markings on back in form of diamond-shaped blotches. *Diamond Rattlesnake* (*Crotalus adamanteus*).
Markings on back in form of dark, ragged-edged cross bands, or sometimes when the animal is very dark, wholly absent. *Banded Rattlesnake* (*Crotalus horridus*).

10. Top of head blackish brown, colors darker. **Cottonmouth* (*Ancistrodon piscivorus*).

* The Cottonmouth is continually confused with the large water snakes of the genus Natrix, which are perfectly harmless.

Top of head reddish, colors paler. *Copperhead* (*Ancistron contortrix*).

11. Upper parts unmarked. 12.
Upperparts with evident markings. 22.

12. Upper parts green. 13.
Upper parts not green. 14.

13. †Scales keeled. *Southern Green Snake* (*Cyclophis aestivus*).
Scales smooth. *Northern Green Snake* (*Liopeltis vernalis*).

14. Color of upper parts black. 15.
Color of upper parts some shade of brown. 17.

15. Snout recurved and keeled. Scales keeled. *Black Adder* (*Heterodon platyrhinus var. niger*).
Snout as usual, not recurved nor keeled. 16.

16. Scales all smooth. Underparts slaty black except the throat which is white. *Black Snake* (*Bascanion constrictor*).
Middle rows of scales faintly keeled. Underparts blackish, except for about the front third, which is white. *Chicken Snake* (*Coluber obsoletus*).

17. Scales keeled. 18.
Scales smooth. 19.

18. Size small, under 1 ft. when adult. *Brown Snake* (*Haldea striatula*).
Size large. Coppery red below. *Copperbelly* (*Natrix f. erythrogastra*).

19. Size large. (Young crossbanded, a foot long when hatched.) *Coachwhip* (*Bascanion flagellum*).
Size small, under one foot when adult. 20.

† The scales of a snake are either perfectly smooth or else with a little ridge down the middle, in the latter case they are said to be keeled.

20. Under parts reddish. *Ground Snake* (*Carphophiops amoenus*).
Under parts whitish or yellowish. 21.

21. Top of head darker than back. Color of back reddish brown. *Brown-headed Snake* (*Rhadinaea flavilata*).
Top of head same color as back. Color of upper parts grayish brown. * *Valerias Snake* (*Virginia valeriae*).

22. Markings confined to red and black blotches on the sides. Under parts red. Size large, scales smooth. *Horn Snake* (*Farancia abacura*).
Markings on upper parts confined to a light or dark cross band on neck. 23.
Back striped or spotted or both. 24.

23. Under parts white, crossband on neck black. *Crowned Tantilla* (*Tantilla coronata*).
Under parts reddish, crossband on neck white. *Brown Snake* (*Haldea striatula*), *some young specimens.*
Under parts yellow, spotted with black, crossband on neck, yellow. *Ringnecked Snake* (*Diadophis punctatus*).

24. Body striped lengthwise. 25.
Body not striped lengthwise. 31.

25. Scales keeled. 26.
Scales, or at least most of the lower rows, smooth. 30.

26. Under parts with dark stripes. *Willow Snake* (*Natrix leberis*).
Under parts not striped. 27.

27. Size small, under 1 ft. when adult. No side stripes but only one down the middle of back. 28.
Size larger, adults over two feet in length. Side stripes usually present. 29.

28. Under parts red. Three pale spots on nape. *Redbellied Snake* (*Storeria occipitomaculata*).

*Valerias Snake usually has small blackish dots on back, but these are not very conspicuous.

Under parts whitish. Not three pale spots on nape. *DeKays Snake* (*Storeria dekayi*).

29. Side stripes on third and fourth rows of scales, counting from belly plates; no square black spots between stripes of side and that on back. *Slim Garter Snake* (*Eutaenia sirtalis*).
Side stripes on second and third rows of scales. Square black spots between stripes. *Garter Snake* (*Eutaenia sirtalis*).

30. Three red stripes on a darker ground. Underparts red, spotted with black. *Hoop Snake* (*Abastor erythrogrammus*).
Four dark stripes on a lighter ground. Underparts yellowish. *Striped Chicken Snake* (*Coluber quadrivittatus*).

31. Body above with crossbands of red, black, and white (or yellow). 32.
Body not colored as above. 34.

32. Every alternate crossbar yellow. *Coral Adder* (*Elaps fulvius*).
Every alternate crossbar black. 33.

33. Snout narrow, under parts white. *Red Snake* (*Cemophora coccinea*).
Snout rounded, under parts with black markings. *Red King Snake* (*Ophibolus doliatus coccineus*).

34. Scales all smooth. 33.
Scales keeled. 42.

35. Black with narrow white crossbars forking on the sides. *King Snake* (*Ophibolus getulus*).
Not as above. 36.

36. Underparts with squarish black spots. 37.
Underparts not with squarish black spots. 38.

37. Head large, broader than the neck. †Anal plate divided. *Spotted Racer. Rat Snake* (*Coluber guttatus*).
Head small, not broader than neck. Anal plate undivided. *Milk Snake* (*Ophibolus doliatus triangulus*).

38. Head large, broader than neck. Anal plate divided. 39.
Head small, not broader than neck. Anal undivided. *Brown King Snake* (*Ophibolus rhombomaculatus*).

39. ‡Scales in 25 or 27 rows. 40.
Scales in 19 rows. 41.

40. Underparts yellowish. *Striped Chicken Snake, young.*
Underparts slaty black behind, whitish in front. *Chicken Snake, young.*

41. §Upper lip plates 7 on each side. *Black Snake, young.*
Upper lip plates 8 on each side. *Coachwhip, young.*

42. Snout recurved and keeled. 43.
Snout not recurved and keeled. 44.

43. Small plate just behind snout plate with several small scales round it. Snout more strongly recurved and keeled. *Hognosed Snake* (*Heterodon simus*).
Small plate just behind snout plate without any small scales round it. Snout less strongly keeled and recurved. *Spreading Adder* (*H. platyrhinus*).

44. Anal plate undivided. Ground color whitish with dark spots on back. *Bull Snake* (*Pityophis melanoleucugs*).
Anal plate divided. 45.

†Anal plate is the plate immediately in front of the vent, which in most of our forms is divided longitudinally into two pieces, but in some it is undivided.

‡Rows of scales are counted diagonally beginning with the row just above the belly plates and are usually uneven in number.

§The upper labials or lip plates are the plates along the edge of the upper lips, excluding the plate at tip of snout.

45. Only the middle rows of scales keeled, size small. **Chicken Snake, young.*

All rows of scales strongly keeled. 46.

46. Spots on back forming crossbars with no alternating spots on sides. *Southern Water Snake* (*Natrix fasciata fasciata*).

Spots on back forming crossbars on front part of body, and on hinder part alternating with spots on the sides. *Common Water Snake* (*Natrix fasciata Sipedon*).

Spots on back alternating with spots on sides from head to tail. *Pied Water Snake* (*Natrix taxispilota*).

NOTES ON THE SPECIES INCLUDED IN THE KEY.

The following species are poisonous: The three species of Rattlesnake (Ground, Banded, and Diamond Rattlesnakes), the Copperhead, and the Cottonmouth, and lastly the Coral Adder, which last belongs to the same group of snakes as the deadly cobra of India. The following harmless snakes are often confused with poisonous species: the Spreading Adder with the Copperhead; the harmless water snakes with the cottonmouth, both forms being indiscriminately known as water moccasins; and the red snake and red king snake with the coral adder.

A few of the species listed have not yet been recorded from North Carolina, these are the coral adder, northern green snake, coachwhip, and milk snake, and we have only one unsatisfactory record of the bull snake.

Of the species included in the key, the following have not yet been taken in this state outside of the lower austral life zone, whose northern boundary in this state appears to be approximately a line drawn from Norfolk through Raleigh, and thence to Charlotte:

*The Southern Chicken Snake (Coluber obsoletus confinis) may possibly occur, in which case the keys for the young of the Chicken Snake would apply to this also. I do not know how the young of the two forms would be distinguished.

Glass Snake, at Raleigh, Garner, Southport, Beaufort.

Green Lizard, at Southport, Wilmington, Beaufort, Lake Ellis, Tryon, and Lumberton.

Hoop Snake, at Newberne, Kinston, Wilmington, Lake Ellis.

Horn Snake, at Newberne, Wilmington, Lake Ellis.

Brown headed Snake at Fort Macon.

Hognosed Snake in Wake Co., at Goldsboro and Lake Ellis.

Spotted Racer at Raleigh, Lake Ellis and Washington.

Striped Chicken Snake, at Newberne and Cape Hatteras.

Red King Snake, at Raleigh.

Red Snake at Raleigh.

Pied Water Snake at Kinston, Avoca, Newberne and Lake Ellis.

Southern Water Snake at Newberne, Wilmington, and Lake Ellis.

Crowned Tantilla at Raleigh.

Cottonmouth at Newberne, Wilmington, Lake Ellis, Cape Hatteras, Beaufort, Washington, and Raleigh.

Ground Rattlesnake, at Wilmington, and Beaufort.

Diamond Rattlesnake at Havelock below Newberne.

Records of the Coral Adder, Coachwhip, Milk Snake, Northern Green Snake, and Bull Snake are very much desired as also records of any other species of snakes and lizards, particularly those confined to the lower austral zone.

Of the four species listed as possibly occurring in the state, the Coral Adder and Coachwhip are confined to the lower austral zone, and should be looked for in the southeastern portion of the state, while the Milk Snake is most apt to be found in the northwest corner. The Northern Green Snake is apt to occur anywhere in the state but is not likely to be common anywhere, and the Bull Snake, of which we have a doubtful record from Wake Co. is liable to occur in the pine woods of the region near the coast.

The other species of snakes and lizards probably occur throughout the entire state, except in portions of the moun-

tain region, but our actual records are few and scattered.

Persons having specimens of any reptile that they are not well acquainted with, would do well to communicate with the Curator of the State Museum at Raleigh, or with myself.

C. S. BRIMLEY,
Newberne Ave., cor. Tarboro St.,
Raleigh, N. C.

(Information is also desired concerning the occurrence of the alligator in the state and also as to the occurrence of the species of soft shelled turtles in the Mississippi drainage as well as in the southeast of the state, the two different parts in which they may possibly occur.)

THE SALAMANDERS OF NORTH CAROLINA

C. S. BRIMLEY

Salamanders are animals which are commonly confused with lizards and which mainly resemble them in external appearance. Their true affinities, in spite of the possession of limbs, are however with the fishes, with which group they and the other amphibians are sometimes combined under the name of Icthyopsida.

They differ externally from from all our lizards in the possession of a moist skin without scales, while all our lizards have a dry scaly skin. The skin in salamanders and other amphibians (frogs and toads) is always moist, and used to some extent (wholly in many species) as an organ of respiration.

The forms which occur or are liable to occur in this state may be recognized by the following key.

KEY TO THE SALAMANDERS OCCURING OR LIABLE TO OCCUR IN NORTH CAROLINA

1. Adults with with external gills, 2.
   Adults without external gills, 5.

2. Hind limbs absent, 3.
   Hind limbs present. Toes 4 on both hind and forefeet, 4.

3. Toes 4. Size large. *Great Siren* (*Siren lacertina*).
   Toes 3. Size small. *Little Siren* (*Pseudobranchus striatus*).

4. Brown with darker spots. Water Dog (*Necturus maculatus*).

Pale unspotted. *Southern Water Dog* (*Necturus punctatus*).

5. Adults with a rounded opening on each side of neck, 6. Adults without a rounded opening on each side of neck, 7.

6. Body eel-shaped, with rudimentary limbs. Toes 2 or 3 each on both fore and hind feet. *Ditch Eel* (*Amphiuma means*).
Body stout, salamander shaped. Toes 4 on fore, 5 on hind feet. *Hellbender* (*Cryptobranchus alleghaniensis*).

7. Tongue mushroom shaped, i. e. a circular disk on a central stalk, 8.
Tongue not attached by a central stalk only, 15.

8. Toes on hind feet 4. Size very small, yellowish brown. *Dwarf Salamander* (*Manculus quadridigitatus*).
Toes on hind feet 5. (Genus Spelerpes), 9.

9. *Costal grooves, 13 or 14. 10.
Costal grooves 15 to 17. 13.

10. Tail about as long as rest of body. Yellow with a dark line along each side of back. Underparts unmarked. *Striped Salamander* (*S. bilineatus*).
Tail 1 1-2 to 2 times as long as body. 11.

11. Color vermilion red, with many brown spots. Tail spotted, not barred. *Spotted tailed Trition* (*S. maculicaudus*).
Color yellow. 12.

12. Underparts marbled with black. Back with a black stripe down middle and another on each side. *Holbrook's Triton* (*S. guttolineatus*).
Underparts unmarked. Back and sides with irregular black spots. *Long-tailed Salamander* (*S. longicauda*).

*Costal grooves are grooves on the sides indicating where the ribs are

13. *Upper jaw bearing on its margin, immediately below each nostril, a prominent tubercule. Color light chocolate brown, spotted with brown. Underparts unmarked. *Daniel's Salamander* (*S. danielsi*).
Upper jaw bearing no such tubercle. 14.

14. Color red of varying shades spotted above or below with black or both. *Red Triton* (*S. ruber*).
Color yellowish or purplish brown above, irregularly blotched with gray. *Purple Salamander* (*S. porphyriticus*).

15. Head with three longitudinal grooves. Underparts yellow or red below with black dots. 16.
Head without longitudinal grooves. 17.

16. Each side with a row of red spots, each spot surrounded by a black ring. *American Newt* (*Diemyctylus viridescens*).
Each side with a series of black bordered red lines, replacing the black ringed spots. *Wilmington Newt* (*D. v. vittatus*).

17. Salamanders with rather long toes on all four feet, the outer and inner ones well developed. Tail compressed. (Genus Ambystoma). 18.
Salamanders with shorter toes, the outer or inner toes or both usually reduced in size or rudimentary. Tail not much compressed. 26.

18. Costal grooves 10. Form short and stout. Color blackish brown with gray, lichen like markings. *Mole Salamander* (*A. talpoideum*).
Costal grooves more than 10. 19.

19. Costal grooves usually 11. 20.
Costal grooves 14. 23.

*Similar tubercles occur more or less frequently in Manculus quadridigitaus, Sp. bilineatus, Sp. guttolineatus and regularly in Sp. maculicauda.

20. Bluish black with gray or white blotches or crossbars on the upper parts of head, body and tail, usually about 12 or 14 in all. Underparts unmarked. *Marbled Salamander* (*A. opacum*).
Not as above. 21.

21. Black with a series of large round yellow spots down each side of back. A strong dorsal groove. *Spotted Salamander* (*A. punctatum*).
Lead colored with one or two series of small yellow spots along sides. No dorsal groove, size small. *Smaller Spotted Salamauder* (*A. conspersum*).
Not as above. 22.

22. Dark brown, yellowish below. No markings. *Sope's Salamander* (*A. Sopeanum*).
Olive brown, yellowish below. Limbs banded, tail spotted. A few ill-defined yellowish spots above. *Two colored Salamander* (*A. bicolor*).

23. Markings grayish or whitish. 24.
Markings brown or yellow. 25.

24. Olive brown or blackish with pale or bluish spots, these sometimes absent. *Jefferson's Salamander* (*A. jeffersonianum*).
Black with a narrow gray line between each pair of costal folds, these either crossing the back undivided to meet their fellows from the opposite side or forking to meet a similiar fork from the other side. Underparts thickly speckled with gray. *Banded Salamander* (*A. cingulatus*).

25. Tail very long, much longer than head and body. *Ohio Salamander* (*A. xiphias*).
Tail about as long as head and body. Color varying from uniform brown to yellow, but usually spotted. *Tiger Salamander* (*A. tigrinum*).

26. Toes on hind feet 4. Underparts with dots like ink spots. *Scaly Salamander* (*Hemidactylium scutatum*).
Toes on hind feet 5. 27.

27. Head with enlarged pores, which give it a pitted appearance. Underparts usually with black dots. Sides with dark longitudinal stripes. *Margined Salamander* (*Stereochilus marginatus*).
Not as above. 28.

28. Tail compressed and finned at least for the apical two thirds. 29.
Tail rounded. 32.

29. Color wholly black above and below. *Black Triton* (*Desmognathus nigra*).
Color not all black. 30.

30. Snout very flat, broad and depressed. Yellowish buff, thickly marked above with confluent black blotches. Underparts unmarked. *Moore's Triton* (*Leurognathus marmoratus*).
Snout more or less arched. 31.

31. Skin of head granulated. Underparts usually more or less uniform slate color. Size rather large. *Mountain Triton* (*Desmognathus quadrimaculatus*).
Skin of head not granulated. Underparts pale. *Brown Triton* (*Desmognathus fusca*).

32. Color brownish yellow, often spotted. *Yellow Salamander* (*Desmognathus ochrophea*).*
Color blackish or plumbeous. (Genus Plethodon.) 33.

33. Color lead-colored with a chestnut red dorsal band, size small. *Redbacked Satamander* (*P. erythronotus*).
Color uniform lead color. *Plumbeous Salamander P. e. cinereus*).
Color black with various markings. 34.

34. Black with red legs. *Sherman Salamander* (*P. Shermani*).

*All the species of the the genus Desmognathus have a peculiar physiognomy which is very characteristic, but not easy to describe.

Black with an orange yellow stripe on sides of head and neck. *Jordan Salamander* (*P. jordani*).
Black with bluish white blotches and specks, occasionaly unspotted. *Slimy Salamander* (*P. glutinosus*).
Black with yellowish green blotches of irregular form on back and sides. *Bronzy Salamander* (*P. aeneus*).

Of the above species the following have not yet been taken in the state: Little Siren, Spotted-tailed Triton, Long-tailed Salamander, Smaller spotted Salamander, Cope's Salamander Two-colored Salamander, Banded Salamander, Ohio Salamander, Scaly Salamander, Jordan Salamander, Bronze Salamander. Most of these however may possibly occur, and some of them are almost certain to be secured with more careful and complete collecting.

The species known to occur in the State have been collected in the following localities:

Great Siren. Craven Co., New Hanover Co.

Water Dog. Wake.

Southern Water Dog. New Hanover.

Ditch Eel. Wake, Edgecombe, Dare, Bertie and Craven.

Hellbender. Yancey.

Dwarf Salamander. Wake, Lenoir.

Striped Salamander. Wake, Buncombe, Yancey, Mitchell and Forsyth.

Holbrook's Triton. Wake, Buncombe, Forsyth, and valley of French Broad.

Daniel's Salamander. Yancey.

Red Triton. Wake, Buncombe, Mitchell, Carteret, Yancey, Burke, Orange, Wayne, Forsyth and Henderson.

Purple Salamander. Mitchell.

American Newt. Wake, Henderson, Lenoir.

Wilmington Newt. New Hanover.

Mole Salamander. Valley of French Broad.

Marbled Salamander. Wake, Edgecombe, Guilford, Columbus, Forsyth, Lenoir.

Spotted Salamander. Wake.

Tiger Salamander. Moore.
Jefferson Salamander. Mitchell.
Redbacked Salamander. Mitchell, Pitt (same localities for Plumbeous S).
Margined Salamander. Craven.
Black Triton. Mitchell.
Moore's Salamander. Grandfather Mt.
Mountain Salamander. Yancey, Mitchell, Henderson.
Brown Triton. Wake, Craven, Forsyth, Lenoir.
Yellow Triton. Yancey, Mitchell.
Sherman Salamander. Nantahala Mt.
Slimy Salamander. Whole State.

A KEY TO THE SPECIES OF FROGS AND TOADS LIABLE TO OCCUR IN NORTH CAROLINA

C. S. BRIMLEY

1. Upper jaw without any teeth. 2.
   Upper jaw with teeth. 5.

2. Skin smooth. Size small. Snout pointed. No paratoid glands (just behind ear). Hind feet not webbed. *Toothless Frog* (*Engystoma carolinense*).
   Skin warty. Paratoids large. Hind feet little webbed. Head with bony ridges above. Toads. 3.

3. Size small, length of head and body one inch. Skin very rough. Bony ridges turning inward almost at right angles just back of the eyes. *Dwarf Toad* (*Bufo quercicus*).
   Size larger, adults about 3 or 4 inches long. Skin not so rough. Bony ridges on top of head not turning abruptly inward back of eyes. 4.

4. Bony ridges ending in a knob behind. *Southern Toad* (*B. lentiginosus*).
   Bony ridges not ending in a knob behind. *Common Toad* (*B. l. americanus*).

5. Paratoids present. Hind feet webbed. Heel with a flat, sharp edged spur. *Solitary Spadefoot Scaphiopus holbrooki*).
   Paratoids absent. No sharp edged spur on heel. 6.

6. Fingers and toes dilated at their tips, this dilation forming a viscous disk. Tree frogs. 7.
   Fingers and toes not much dilated at tips. 13.

7. Back with a dark x-shaped mark, size small. *Peeper* (*Hyla pickeringi*).
Back marked or not, but if marked, the markings do not form an x-shaped mark. 8.

8. Back of thigh not marked with yellow spots or variegations. 9.
Back of thigh with yellow spots or variegations. 11.

9. A yellow band on upper lip and sides of body, sharply defined above and below. Back with minute yellowish spots. *Carolina Tree Frog* (*Hyla cinerea*).
Yellow or white band on sides not sharply defined above and below. 10.

10. Size large, feet edged with yellow. *Georgia Tree Frog* (*H. gratiosa*).
Size small, feet not edged with yellow. *Squirrel Tree Frog* (*H. squirella*).

11. Size large, skin of back rough. A light spot on upper jaw just below eye. *Common Tree Frog* (*H. versicolor*).
No light spot below eye. 12.

12. A plum colored line along sides of body with yellow spots below it. *Anderson's Tree Frog* (*H. andersoni*).
No yellow spots on sides. *Pine woods Tree Frog* (*H. femoralis*).

13. Feet unwebbed, size small. (Genus Chorophilus). 14.
Feet more or less webbed. 15.

14. Skin of upper surface granulated. *Chorus Frog* (*C. nigritus and subspecies*).
Skin of upper surface smooth, a dark patch on ear. *Smooth Chorus Frog* (*C. occidentalis*).

15. Size small. Skin above warty. A dark triangle between eyes. *Cricket Frog* (*Acris gryllus*).
Size larger. Skin above smooth. 16.

16. A ridge of raised skin along each side of back. 17.
No narrow ridge of raised skin along side of back. 19.

17. A black ear patch. *Wood Frog* (*Rana sylvatica*).
    No black ear patch. 18.
18. Fold of skin down each side of back white. Back with large dark spots. *Leopard Frog* (*Rana pipiens*).
    Fold of skin down each side of back the same color as back. Back with a few small dark spots or none. *Spring Frog* (*Rana clamata*).
19. Back with large dark spots in two rows. Size medium. *Pickerel Frog* (*Rana palustris*).
    Back with irregular dark spots or none. Size large. *Bullfrog* (*Rana catesbiana*).
    Sides with two light brown longitudinal bands. *Cope's Frog* (*Rana virgatipes*).

Of the species included in the key the following have not yet to my knowledge been recorded from from North Carolina: Anderson's Tree Frog, Georgia Tree Frog, Smooth Chorus Frog, and Southern Toad.

The other species have been taken in the following localities:

Toothless Frog. Wake, Johnston and Wayne Co's.

Dwarf Toad. Lenoir and Carteret.

Common Toad. Forsyth, Wake, Jackson, Craven, Lenoir and Wayne.

Solitary Spadefoot. Wake.

Peeper. Wake, Mitchell, Wayne, Johnston, Guilford.

Carolina Tree Frog. Lenoir and Dare.

Squirrel Tree Frog. Dare, Craven, Brunswick.

Pine woods Tree Frog. Craven and New Hanover.

Common Tree Frog. Wake, Wayne, Forsyth Pitt.

Chorus Frog. Guilford and Wake.

Cricket Frog. Wake, Craven, Wayne, Forsyth, Guilford.

Wood Frog. Lenoir.

Pickerel Frog. Wake, Mitchell, Lenoir.

Leopard Frog. Wake, Craven, Edgecombe, Dare.

Spring Frog. Craven, Wake, Forsyth, Guilford, Mitchell.

Bullfrog. Wake, Craven, Edgecombe.

Cope's Frog. Craven.

These keys (to snakes and lizards, salamanders, and to toads and frogs) have been prepared with the idea of giving intelligent persons without special knowledge on the subject an opportunity of identifying our native forms of these groups. The keys must not be expected to be infallible though I have endeavored to make them as accurate as possible.

ON SOME PHENOMENA OF COALESCENCE AND REGENERATION IN SPONGES[1]

BY H. V. WILSON

I

In a recent communication I described some degenerative and regenerative phenomena in sponges and pointed out that a knowledge of these powers made it possible for us to grow sponges in a new way. The gist of the matter is that silicious sponges when kept in confinement under proper conditions degenerate in such a manner that while the bulk of the sponge dies, the cells in certain regions become aggregated to form lumps of undifferentiated tissue. Such lumps or plasmodial masses, which may be exceedingly abundant, are often of a rounded shape resembling gemmules, more especially the simpler gemmules of marine sponges (Chalina, *e. g.*), and were shown to possess in at least one form (Stylotella) full regenerative power. When isolated they grow and differentiate, producing perfect sponges. I described moreover a simple method by which plasmodial masses of the same appearance could be directly produced (in Microciona). The sponge was kept in aquarium until the degenerative process had begun. It was then teased with needles so as to liberate cells and cell agglomerates. These were brought together with the result that they fused and formed masses similar in appearance to those produced in this species when the sponge remains quietly in aquarium. At the time I was forced to

1Reprinted from Journal of Experimental Zoölogy, vol. v, no. 2., and published with the permission of Hon. Geo. M. Bowers, U. S. Commissioner of Fisheries.

leave it an open question whether the masses of teased tissue were able to regenerate the sponge body.

During the past summer's work at the Beaufort Laboratory[2] I again took up this question and am now in a position to state that the dissociated cells of silicious sponges after removal from the body will combine to form syncytial masses that have power to differentiate into new sponges. In Microciona, the form especially worked on, nothing is easier than to obtain by this method hundreds of young sponges with well developed canal system and flagellated chambers. How hardy sponges produced in this artificial way are and how perfectly they will differentiate the characteristic skeleton, are questions that must be left for more prolonged experimentation.

Taking up the matter where it had been left at the end of the preceding summer, I soon found that it was not necessary to allow the sponge to pass into a degenerative state, but that the fresh and normal sponge could be used from which to obtain the teased out cells. Again in order to get the cells in quantity and yet as free as possible from bits of the parent skeleton, I devised a substitute for the teasing method. The method adopted is rough but effective.

Let me briefly describe the facts for Microciona. This species (M. prolifera Verr.) in the younger state is incrusting. As it grows older it throws up lobes and this may go so far that the habitus becomes bushy. The skeletal framework consists of strong horny fibers with embedded spicules. Lobes of the sponge are cut into small pieces with scissors and then strained through fine bolting cloth such as is used for tow nets. A square piece of cloth is folded like a bag around the bits of sponge and is immersed in a saucer of filtered sea-water. While the bag is kept closed with the fingers of one hand it is squeezed between the arms of a small pair of forceps. The pressure and the elastic recoil of the

[2]I am indebted to the director of the station, Mr. H. D. Aller, for his kindly aid in supplying all facilities needed in the course of my investigation.

skeleton break up the living tissue of the sponge into its constituent cells, and these pass out through the pores of the bolting cloth into the surrounding water. The cells, which pass out in such quantity as to present the appearance of red clouds, quickly settle down over the bottom of the saucer like a fine sediment. Enough tissue is squeezed out to cover the bottom well. The cells display amœboid activities and attach to the substratum. Moreover they begin at once to fuse with one another. After allowing time for the cells to settle and attach, the water is poured off and fresh sea-water added. The tissue is freed by currents of the pipette from the bottom and is collected in the center of the saucer. Fusion between the individual cells has by this time gone on to such an extent that the tissue now exists in the shape of minute balls or cell conglomerates of a more or less rounded shape looking to the eye much like small invertebrate eggs. Microscopic examination shows that between these little masses free cells also exist, but the masses are constantly incorporating such cells. The tissue in this shape is easily handled. It may be sucked up to fill a pipette and then strewn over cover glasses, slides, bolting cloth, watch glasses, etc. The cell conglomerates which are true syncytial masses throw out pseudopodia all over the surface and neighboring conglomerates fuse together to form larger masses, some rounded, some irregular. The details of later behavior vary, being largely dependent on the amount of tissue which is deposited in a spot, and on the strength of attachment between the mass of tissue and the substratum.

Decidedly the best results are obtained when the tissue has been strewn rather sparsely on slides and covers. The syncytial masses at first compact and more or less rounded, flatten out, becoming incrusting. They continue to fuse with one another and thus the whole cover glass may come to be occupied by a single incrustation, or there may be in the end several such. If the cover glass is examined at intervals, it will be found that differentiation is gradually taking place. The dense homogeneous syncytial mass first develops at

the surface a thin membrane with underlying connective tissue (collenchyma). Flagellated chambers make their appearance in great abundance. Canals appear as isolated spaces which come to connect with one another. Short oscular tubes with terminal oscula develop as vertical projections from the flat incrustation. If the incrustation be of any size it produces several such tubes. The currents from the oscula are easily observed, and if the cover glass be mounted in an inverted position on a slide the movements of the flagella of the collar cells may be watched with a high power (Zeiss 2 mm.). This degree of differentiation is attained in the course of six or seven days when the preparations are kept in laboratory aquaria (dishes in which the water is changed answer about as well as running aquaria). Differentiation goes on more rapidly when the preparation is hung in the open harbor in a live-box (a slide preparation inclosed in a coarse wire cage is convenient). Sponges reared in this way have been kept for a couple of weeks. The currents of water passing through them are certainly active and the sponges appear to be healthy. In such a sponge spicules are present, but some of these have unquestionably been carried over from the parent body along with the squeezed out cells.

The old question of individuality may receive a word here. Microciona is one of that large class of monaxonid sponges which lack definite shape and in which the number of oscula is correlated simply with the size of the mass. While we may look on such a mass from the phylogenetic standpoint as a corm, we speak of it as an individual. Yet it is an individual of which with the stroke of a knife we can make two. Or conversely it is an individual which may be made to fuse with another, the two forming one. To such a mass the ordinary idea of the individual is not applicable. It is only a mass large or small having the characteristic organs and tissues of the species but in which the shape of the whole and the number of the organs are indefinite. As with the adult so with the lumps of regenerative tissue. They have no definiteness of shape or size, and their structure is only definite

in so far as the histological character of the syncytial mass is fixed for the species. A tiny lump may metamorphose into a sponge, or may first fuse with many such lumps, the aggregate also producing but a single sponge although a larger one. In a word we are not dealing with embryonic bodies of complicated organization but with a reproductive or regenerative tissue which we may start on its upward path of differentiation in almost any desired quantity. A striking illustration of this nature of the material is afforded by the following experiment. The tissue in the shape of tiny lumps was poured out in such wise that it formed continuous sheets about one millimeter thick. Such sheets were then cut into pieces, each about one cubic millimeter. These were hung in bolting cloth bags in an outside live-box. Some of the pieces in spite of such rough handling metamorphosed into functional sponges.

Even where the embryonic bodies of sponges have a fixed structure and size, as in the case of the ciliated larva, the potential nature as displayed in later development, is not fixed in the matter of individuality. Such a body may form a single individual or may fuse with some of its fellows to form a larger individual differing from the one-larva sponge only in size. It is then in spite of its definiteness of shape and size, essentially like a lump of regenerative tissue in that whether it develops into a whole sponge or a part of a sponge depends not on its own structure but on whether it is given a good opportunity of fusing with a similar mass. A parallel case to the coalescence of larvæ is afforded by the gemmules of fresh water sponges. Mr. M. E. Henriksen in a manuscript account submitted to me a year ago, describes the fusion of gemmules to form a single sponge.

In the preceding description I have passed over the question as to the precise nature of the cells which combine to form the masses of regenerative tissue. On this point as on the histological details in general I hope to have more to say later. Nevertheless the phenomena are so simple that observation of the living tissue reveals much, probably indeed all

that is of fundamental importance. If a fairly dense drop of the squeezed out tissue be mounted at once and examined with a high power (Zeiss 2 mm., comp. oc. 6), the preparation is seen to consist of fluid (sea-water) with a few spicules and myriads of separate cells. The cells fall into three classes.

1 The most conspicuous and abundant are spheroidal, reddish, densely granular, and about 8μ in diameter. These cells which can be nothing but the unspecialized, amœboid cells of the mesenchyme (amœbocytes or archæocytes), put out hyaline pseudopodia that are sometimes elongated, more often rounded and blunt.

2 There is also a great abundance of partially transformed collar cells, each consisting of an elongated body with slender flagellum. The cell is without the collar, the latter doubtless having been retracted. In the freshly prepared tissue the flagella are vibratile, the cells moving about. Soon however the flagellum ceases to vibrate.

3. The third class is not homogeneous. In it I include more or less spheroidal cells ranging from the size of the granular cells down to much smaller ones. Many of these are completely hyaline, while others consist of hyaline protoplasm containing one or a few granules.

Fusion of the granular cells begins immediately and in a few minutes time most of them have united to form small conglomerate masses which at the surface display both blunt and elongated pseudopodia. These masses soon begin to incorporate the neighboring collar and hyaline cells. One sees collar cells sticking fast by the end of the long flagellum to the conglomerate mass. Other collar cells are attached to the mass by short flagella. Still again only the body of the collar cell projects from the mass while there is no sign of flagellum. Similarly spheroidal hyaline cells of many sizes are found in various stages of fusion with the granular conglomerate. In such a preparation the space under the cover glass is soon occupied by innumerable masses or balls of the kind just described, between which continue to lie abundant free cells, some collar cells, others hyaline. Practically all

the granular cells go to make up the balls. The play of pseudopodia at the periphery of such balls, which results in the incorporation of free cells and in the fusion of balls to form larger masses, is easily watched. Along with such a cover glass preparation it is convenient to have some of the squeezed-out tissue in a watch glass of sea-water. In the watch glass preparation it is instructive to watch with a two-thirds or one-half objective the fusion of the cell conglomerates to form masses like those strewn on covers, slides, etc.

These observations on the early steps in the formation of the masses of regenerative tissue make it plain that such masses are composed chiefly of the spheroidal, granular cells (amœbocytes or archæocytes), but that nevertheless other cells, collar cells and more or less hyaline cells also enter into their composition. I may recall the fact that in the formation of regenerative masses in a degenerating sponge,[3] the evidence from sections, which is the only evidence available in the case, points to the conclusion that the collar cells help to form the syncytial tissue of the masses. The question of interest lying at the heart of this matter may be so formulated: can particles of the Microciona protoplasm differentiate into functional collar cells and, when the occasion arises, change back into unspecialized masses capable of combining with other masses of unspecialized protoplasm to form a regenerative body? The facts to which I have just alluded support this idea, and indicate that the immediate problem is one worth pursuing farther as a good case of temporary differentiation of protoplasm in the metazoa analogous to the temporary specialization of the cell individual which occurs in such colonial protazoa as Protospongia.[4]

As far as the amœbocytes are concerned it is certain that they have great regenerative power. Weltner in a recent

[3] A new method by which sponges may be artificially reared, Science, n. s., vol. xxv, no. 649, 1907.

[4] Metschnikoff, Embryologische Studien an Medusen, p. 147, 1886.

paper[5] has emphasized the importance of these unspecialized cells in the process of growth and regeneration. His conclusions which refer directly to fresh water sponges, are that in a growing sponge, in a sponge regenerating new organs after its winter period of simplification, and in the regeneration of a sponge from a cutting, the amœbocytes are the all-powerful elements in that they give rise to all the new tissues formed. He further alludes to the fact that such reproductive bodies as the gemmules of fresh water sponges and the buds of Tethya (according to Maas) are only groups of amœbocytes; further that the gemmules of Tedania and Esperella described by Wilson as developing into ciliated larvæ, and the similar bodies found by Ijima in hexactinellids, are such groups. I may add that the presence of such groups of unspecialized cells in the hexactinellids has recently been confirmed by the master in sponge-morpholagy, F. E. Schulze, who recognizes the probability of their reproductive nature and gives them a new name, that of *sorites*.[6] It is clear then that in many sponges reproductive bodies are formed by the association of unspecialized amœboid cells. But there is nothing in this fact which precludes the possibility that the groups of amœbocytes are in part recruited from transformed collar cells and other tissue cells, such as pinacocytes (flat cells of canal walls), that have undergone regressive differentiation into an unspecialized amœboid condition.

Cells analogous to the amœbocytes of sponges are found elsewhere in the metazoa, *e. g.*, in the ascidians.[7] It would be interesting to know what capacity, if any, for development they have, when freed from the parent (bud) and collected together in sea-water.

[5] Spongilliden-studien V. Zur Biologie von Ephydatia fluviatilis und die Bedeutung der Amœbocyten für die Spongilliden. Archiv für Naturgeschichte, 73 Jahrg., 1 Bd., 2 Heft, 1907.

[6] Wissensch. Ergebn. d. Deutsch. Tiefsee-Exp. 1898-99. Hexactinellida, pp. 213-15. Jena, 1904.

[7] Comp. Hjort's and Lefevre's papers on budding in ascidians.

II

I shall here briefly record some experiments which gave only negative results but which under circumstances admitting of a wider choice of species, ought to yield returns of value. These experiments were based on the assumption that if the dissociated cells of a species will recombine to form a regenerative mass and eventually a new sponge, the dissociated cells of two different species may be made to combine and thus form a composite mass bearing potentially the two sets of species-characteristics. It is clear that such an organism would be analogous to one produced by an association of the blastomeres of the two species. Pending the successful carrying out of this experiment, it would be idle to discuss further the nature of the hypothetical dual organism.

In my own experiments three sponges were used: Microciona, Lissodendoryx and Stylotella. The three are all monactinellids but Microciona is the only one in which the skeleton includes any considerable amount of horny substance. Dissociated cells of Microciona and Lissodendoryx were mixed, and again dissociated cells of Microciona were mixed with those of Stylotella. In each case the experiment was performed at two different times, and a considerable number of admixtures, in watch glasses and on cover glasses, was made. The preparations were examined at short intervals with the microscope. The cells of these three species are colored very differently, and are therefore easily distinguished, at least as soon as fusion sets in and little masses of cells begin to be formed. In all the experiments the cells and cell-masses of a species combined and not the cells of different species. Thus in the admixture of Microciona and Lissodendoryx, Microciona regenerative masses and Lissodendoryx regenerative masses were produced. Similarly when Microciona and Stylotella cells were mixed, the resultant masses were pure, some Microciona, some Stylotella. The Microciona masses in these experiments were hardy. They continued to develop and in some preparations metamorphosed. The cell masses of the other two species while they reached a considerable size were

not hardy, most dying soon although some began the process of metamorphosis.

These three species are so unlike that there was little ground in the beginning for the expectation that coalescence would take place. Possibly as in the cases where fusion of egg and sperm of different species is induced through some alteration in the physiological state of protoplasm, so the generative cells and cell masses of different species may be made to combine under abnormal conditions. The more promising task is however to find allied species and subspecies, the regenerative tissue of which will combine under natural conditions. Such forms, I take it, should be sought among the horny sponges and the monactinellids with abundant horny matter.

III

The tendency to fuse so vigorously displayed by the cells and cell masses of regenerative tissue led me to examine into the power that larvæ have to fuse with one another and the capacity for development in the resultant mass. Delage and others have remarked on the not infrequent occurrence of fusion between sponge larvæ. Delage[8] says that he has often observed two or several larvæ unite to form a single sponge "which has from the start several cloacas."

I find that this power to fuse displayed by the larvæ is one that is easy to control. Fusion between the larvæ will readily take place if they are brought in contact at the critical time when the ciliated epithelium is being replaced by the permanent flat epithelium. At this time they will fuse in twos or threes or in larger number up to and over one hundred. The smaller composite masses composed of as many as five or six larvæ metamorphose into sponges. The larger masses composed of many larvæ did not metamorphose in my experiments but experience with the regenerative tissue suggests that such masses would metamorphose if certain mechanical difficulties due to the great size of the mass were

8 Embryongénie des Eponges. Arch. de Zool. Exp. et Gén., p. 400, 1892.

removed. Possibly this might be accomplished by cutting a flattened sheet composed of some hundred larvæ (such as I have produced) into pieces and inducing the pieces to metamorphose separately.

I may now describe some of the details in this process of larva-fusion. In a species of Lissodendoryx used the larva is of the following character. It has the usual ovoidal shape with a protuberant non-ciliated pole. The anterior pole is somewhat truncated and is sparsely ciliated. The rest of the body bears the usual thick covering of cilia. As seen with reflected light the bulk of the body is dead white, the posterior pole deep blue, and the anterior pole bluish. This coloration is not absolutely fixed for the species, but the larvæ used in my coalescence experiments were all of this character. Within twenty-four hours after liberation the ciliated larvæ are creeping (remaining in contact with the bottom as they swim) over the bottom of the dish. Some are now put in deep round watch glasses and with pipette and needle coaxed together into a clump. Fusion soon begins and on the next day plenty of composite larvæ are present. The larvæ fuse endwise, for the most part in pairs. The compound larva so produced owing to its weight has a very feeble locomotory power. Using pairs that are nearly motionless, larvæ may be brought together (coaxed with needle) and arranged in a desired position on a cover glass for instance. In successful cases fusion results before the separate masses move apart. In this way, selecting an instance, I have added to one arm of a quadruple mass a pair of larvæ, and to the opposite arm two pairs,

For the purpose of bringing about the fusion of many larvæ the following simple method is convenient. Suppose that we have the larvæ in a paraffine-coated dish, and they are in a late "creeping" stage. Small excavations, 2–3 mm. deep and 4–5 mm. wide, are now made in the paraffine, and with the pipette the larvæ are driven into the holes. They lie here in numbers up to and over one hundred, crowded together and heaped upon one another. Fusion begins soon

and the larvæ are gradually converted into a flattened cake. The larger cakes thus made measured four by three millimeters. The body of such a cake is a continuous flattened mass in which there is no indication of the component larvæ, but the rounded ends of the larvæ that have last fused with the general mass remain for a time distinguishable. Owing to their blue coloration the ends of the larvæ may be recognized in these and the other compound masses even after the outline of the larva has been completely lost.

As already stated the smaller compound masses metamorphose without difficulty. The coalesced larvæ may be made to attach to cover glasses, slides, etc. Larger masses composed of about twenty larvæ underwent a partial metamorphosis. Such masses were laid upon bolting cloth to which they readily attached. The larges masses were hung in small bolting cloth bags in a live box. Whether owing to bad handling or more probably to some inherent difficulty, they did not metamorphose but soon died.

The ease with which larvæ of the same species may be made to fuse together suggests that larvæ of different species might likewise be induced to coalesce. Some experiments along this line could not fail to be of interest.

IV

In the tendency to fuse with the production of a plasmodium, the dissociated cells of sponges resemble the amœbocytes (amœbulæ) of the mycetozoa and Protomyxa. The regenerative power of the plasmodium has an interest both theoretical and economic in itself. But it is the tendency to fuse displayed by the cells that have been forcibly broken apart, which constitutes the fact of most general physiological importance. Discarding for the moment the word "cell" and speaking of the protoplasm of a species as a specific substance, the phenomena may be restated to advantage in the following way.

A mass of sponge protoplasm in the unspecialized state typically exhibits pseudopodial activities at the surface. In

lieu of more precise knowledge it is useful to regard the pseudopodia as structures which explore and learn about the environment. On coming in contact two masses of the same specific protoplasm tend to fuse. This tendency is probably useful (*i. e.*, adaptive) in that the additional safety (from enemies and "accidents") accruing from increase in size of the mass more than compensates for the reduction in number of the individual masses that start to grow (rearing of sponges shows that masses of good size frequently withstand conditions that effectually wipe out the very small masses.) Unlike specific substances (protoplasms of quite different species) do not tend to fuse.

To the many biologists who have found ideas and observations of deep interest in the papers on protoplasmic activities by Professor and Mrs. E. A. Andrews (G. F. Andrews), the statement just made will have a familiar sound. Mrs. Andrews in her essay on The Living Substance as Such and as Organism[9] and her paper on The Spinning Activities of Protoplasm[10] makes, it would appear from subsequent confirmations, a definite advance in our knowledge of the intimate structure of protoplasm. But it is her generalizations, based on singularly acute observations, with respect to the *behavior* of protoplasm, that have especially influenced my own work. The particular generalizations referred to may be so formulated:

1 Protoplasm tends to produce a viscous, pellicular layer, with formation of pseudopodial outgrowths over the surface, whether external or internal to the mass, which establishes contact with the environmental medium.

2 Pseudopodia from adjacent masses of the same specific substance tend to fuse. Thus actual connections which can be made and remade, and along which transference of substance takes place, are established between the masses.

That these phenomena are observable in widely separated groups of metazoa has been also shown by Professor Andrews

9 Suppl. to Journ. Morphology, vol. xii, no. 2, 1897.

10 Journ. Morphology, 1897.

in a series of brief studies marked with his well known skill and accuracy of observation and statement. I fully agree with him as to the great importance of the facts.

The general point of view entertained by Mrs. Andrews in her much discussed essay is perhaps not everywhere clear to me. It is manifest however that she consistently subordinates the idea of the individual, whether entire organism or cell, to that of the specific substance of which it is but a more or less detached piece. As far as the cell is concerned this point of view seems to be essentially that of Sachs and Whitman. Mrs. Andrews extends it to the whole organism, and I may say that this way of looking at an animal or plant (or piece of the same) is in my opinion a habit of mind that will justify itself and indeed is doing so today, in that it leads to discoveries concerning the nature of protoplasms as revealed by what they can do.

University of North Carolina,
Chapel Hill, N. C.
October 29, 1907.

FISHES OF NORTH CAROLINA; A REVIEW

BY JOSEPH HYDE PRATT

There has just been issued by the North Carolina Geological and Economic Survey Volume II on The Fishes of North Carolina. This volume has been prepared for the Survey by Dr. H. M. Smith, Deputy U. S. Commissioner of Fisheries. The object of this publication is to give to the people of North Carolina and to others a more accurate knowledge of the abundance, distribution, habits, migrations, spawning, food value, etc., of the fishes in the belief that such knowledge will lead to a fuller realization of the economic importance of the fishery resources to the State. For this reason, it has been the special aim to make the report useful to all the fishing interests of the State. No essential technical considerations have been slighted but the scientific treatment has been adapted to the needs of fishermen and others who have had no opportunity to study ichthyology. It is most desirable that there be created a deeper interest in the welfare of both fishes and fishermen and a better understanding of the conditions and needs of the fishing industry with a view of placing this important branch on a permanent basis and making it yield an increasing revenue to both State and people. This volume will also be of interest to the layman and perhaps of special interest to the angler, as he will be able to make use of the work in the identification of species. As the scientific aspects of the subject have not been neglected, the work will also be found to have a value to icthyologists and zoologists in general.

As a means of identifying any fish that may be taken in any waters of the State, artificial keys have been prepared based on the external characters that commercial fishermen and anglers may readily appreciate and, further, there is a copious index of common names which gives a further clue to all the species whose size makes them objects of capture.

As Dr. Smith states: "Although the fish life of North Carolina is not of a new or distinctive type and bears a rather close resemblance to that of the adjoining States, it does nevertheless have some features of exceptional interest."

On account of the great variation in the topography of the State, the number, length and volume of the rivers and streams, the large, shallow sounds which fringe the coast, the long coast-line, and the wide variation in climatic conditions, there has been developed in North Carolina a fish fauna rich in both species and individuals. Some of the species found in North Carolina are peculiar to this State, while others which were first identified in this State, have later been found elsewhere. Other species exist in much greater greater abundance in this State than in others.

Among the more prominent features of the fish fauna in North Carolina, Dr. Smith mentions the following:

"(a) The abundance of certain anadromous fishes, whose numbers are scarcely surpassed in any other waters, the chief of these being the shad, the alewives, and the striped bass.

"(b) The variety and abundance of suckers, minnows, and sun-fishes in the fresh waters generally, and of darters in the headwaters of the streams on both sides of the Alleghanies.

"(c) The occurence in the sounds and along the outer shores of immense schools of mullet, squeteague, menhaden, blue-fish, croaker, spot, pig-fish, pin-fish and other food fishes.

"(d) The extension to the North Carolina coast of many species which are characteristic of the West Indies or Florida.

"(e) A few species of the Atlantic coast reach their southern limit in North Carolina (such as the cod and tautog) or

PRESENT IDENTIFICATION	ORIGIN
SILURIDÆ:	
Schilbeodes furiosus*	Noturus fu
CATOSTOMIDÆ:	
Moxostoma papillosum	Ptychoston
Moxostoma collapsum*	Ptychoston
Moxostoma pidiense*	Ptychoston
Moxostoma coregonus*	Ptychoston
Moxostoma album*	Ptychoston
Moxostoma thalassinum*	Ptychoston sinus
Moxostoma robustum*	Ptychoston
Moxostoma crassilabre*	Ptychoston bris
Moxastoma conus*	Ptychoston
Moxostoma rupiscartes	Moxostoma
CYPRINIDAE:	
Notropis pyrrhomelas	Photogenis
Notropis niveus	Hybopsis ni
Notropis chlorocephalus	Hybopsis c
Notropis brimleyi*	Notropis br
Notropis chiliticus*	Hybopsis ch
Notropis altipinnis*	Alburnellus
Notropis umbratilis matutinus*	Alburnellus
Hybopis labrosus	Ceratichthy
Hybopis hysinotus	Ceratichthy
PŒCILIIDAE:	
Fundulus rathbuni*	Fundulus ra
EXOCŒTIDAE:	
Cypselurus lutkeni*	Exocœtus l
PERCIDAE:	
Boleosoma maculaticeps*	Boleosoma
Etheostoma rufilineatum	Pœcilicihthy um
Etheostoma swannanoa*	Etheostoma
Etheostoma vulneratum	Pœcilichthy
Ioa vitrea	Pœcilichthy
TRIGLIDAE:	
Prionotus scitulus	Prionotus sc
GOBIIDAE:	
Microgobius holmesi *	Microgobius

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do not occur in noteworthy numbers further south (such as the white perch and striped bass)."

There have thus far been described from North Carolina waters 345 different species of fish; one species of lancelet; and one of lamprey. This number includes several species that have been introduced into the waters of North Carolina but which have become more or less established. Of these, 209 are marine or brackish water species; 125 are fresh water species; and 11 are anadromous or catadromous species.

Of this number, 29 species of fish were first described from North Carolina waters, of which 18 have as yet been found in no other State. These species are given in the following table together with the name of the species as described in the volume, name under which it was first described, the common name, type, locality, and the person by whom named and the date when the species was established. Those species marked by an asterisk have not been found as yet in any other State.

Under the heading of Systematic Catalogue of North Carolina fishes there is given a full list of all the species of fishes known to inhabit the fresh or salt waters of North Carolina and under each species there is given its technical name and original describer, its popular names, a brief synonomy, a diagnostic description and then a general account of their distribution, abundance, size, habits, food value, economic importance, etc., which have special reference to North Carolina. As an aid to the diagnostic description, a figure is given which shows the parts referred to and the names which designate them (Fig. 1)

Of the three great classes into which fishes and fish-like animals are divided, only the third is important in connection with the fishes of North Carolina, as the first two classes contain only one representative each. These classes are as follows:

KEY TO THE CLASSES OF FISHES AND FISH-LIKE ANIMALS

i. Animals with cartilaginous skeleton and without brain or skull; fins rudimentary and only on median line of body; mouth a slit surrounded by bristles; heart a tubular vessel without separate chambers; blood colorless; gillslits numerous, the respiratory cavity opening into the abdomen; inspired water discharged through a special abdominal pore.

LEPTOCARDII (lancelets).

ii. Animals with cartilaginous or bony skeleton; skull and brain present; heart developed as a cavity with at least two chambers; blood red.

a. Eel-shaped; skeleton cartilaginous; skull imperfect; mouth circular, suctorial; no jaws or paired fins; a single median nostril; gills pouch-shaped and numerous; skin naked; alimentary canal straight, without cœca; pancreas and spleen absent.

MARSIPOBRANCHII (lampreys, etc.)

aa. Skull well-developed; jaws distinct; fins usually highly-developed, some of them paired; skin usually scaly; nostrils at least two, not median; gill-openings a single slit on each side in most fishes (numerous in a few families); alimentary canal more or less convoluted; pancreas and spleen present.

PISCES (fishes).

Of the third class, Pisces, the North Carolina representatives fall into two easily recognized groups or sub-classes: (1) the Shark, Skates and Rays and (2) the True Fishes, which are distinguished anatomically as follows:

i. Skeleton cartilaginous; skull without sutures and without membranous bones; gill openings numerous (5 to 7) and slit like, the gills attached to the skin; tail heterocercal; skin tough, naked or covered with small rough scales, spines, or tubercles; air-bladder absent; jaws separable from skull; species viviparous or ovoviviparous, the eggs large and few in number; embryo with deciduous external gills.

SELACHII OR ELASMOBRANCHII (sharks, skates, rays, etc.)

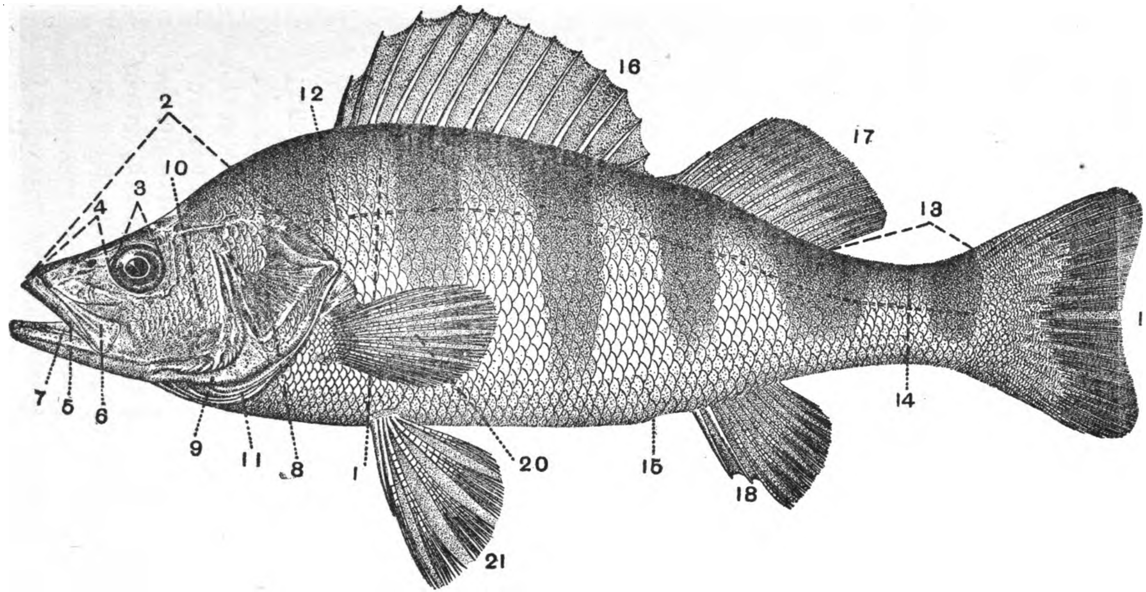

Fig. 1. CUT OF YELLOW PERCH SHOWING PARTS USUALLY REFERRED TO IN DESCRIPTIONS

1. Depth
2. Head
3. Eye
4. Snout
5. Premaxillary
6. Maxillary
7. Lower Jaw
8. Opercle
9. Subopercle
10. Preopercle and cheek
11. Branchiostegals
12. Lateral line
13. Length of caudal peduncle
14. Depth of caudal peduncle
15. Vent
16. Spinous dorsal fin
17. Soft dorsal fin
18. Anal fin
19. Caudal fin
20. Pectoral fin
21. Ventral fin

ii. Skeleton bony in all but a few families; skull with sutures and membranous bones (opercula, etc.); gill-openings a single slit on each side, the gills attached to bony arches; tail heterocercal or homocercal; body usually covered with numerous flat scales; air-bladder present or absent; jaws not distinct from the skull; species oviparous (exceptionally viviparous), the ova small and numerous.

TELEOSTOMI (true fishes).

In the first class are included 9 species of shark and 11 species of rays. In the second class (true fishes) there are 325 species. The 12 largest families included in these are as follows:

Cat-fishes	12	species	in	4	genera.
Suckers	18	"	"	5	"
Minnows	36	"	"	9	"
Killi-fishes	9	"	"	5	"
Mackerels	8	"	"	6	"
Carangids	17	"	"	8	"
Sun-fishes	17	"	"	10	"
Perches	24	"	"	12	"
Sea basses	11	"	"	7	"
Sparids	7	"	"	6	"
Drums	14	"	"	10	"
Flounders	11	"	"	7	"

The fisheries of North Carolina are of considerable economic importance to the State, approximating in value $2,000,000 per year, the catch being utilized largely for food purposes. Of the 347 species listed, there are about 90 that are of present commercial value, most of which are used for food. In the following table there is given a list of those that are used for this purpose. In this table there is given the common as well as the scientific name.

FISHES USED FOR FOOD IN NORTH CAROLINA.

Sturgeon (*Acipenser oxyrhynchus*).
Suckers (Family Catostomidae. North Carolina has more species of suckers than any other State; 8 species used as food).
Red Horse (*Moxostoma Crassilabre*).
Choly; shiner (*Hybognathus Nuchalis*).
Horned dace (*Semotilus Atromaculatus*).
Roach; shiner (*Notemigonus Crysoleucas*).
Carp (*Cyprinus Carpio*).
Eel, fresh-water eel (*Anguilla Chrisypa*).
Sea Herring (*Clupda Harengus Linnaeus*).
Hickory Shad (*Pomolobus Mediocris*).
Branch Herring, Alewife (*Pomolobus Pseudoharengus*).
Glut Herring, Shoal Herring (*Pomolobus Aestivalis*).
Shad (*Alosa Sapidissima*).
Menhaden (*Brevoortia Tyrannus*).
Brook Trout; Mountain Trout (*Salvelinus Fontinalis*).
Rainbow Trout; California Trout (*Salmo Irideus*).
Pike; Pickerel (*Esox Americanus* and *Esox Reticulatus*).
Mullets (*Mugil Cephalus* and *Mugil Curema*).
Bonito (*Sarda* Sarda) variety of mackerel.
Spanish Mackerel (*Scomberomorus Maculatus*).
Cero (*Scomberomorus Regalis* and *Cavalla*).
Sword-fish (*Xiphias Gladius*).
Pompano; Sun-fish (*Trachinotus Carolinus*).
Blue-fish (*Pomatomus Saltatrix*).
Cabio; Crab-eater (*Rachycentron Canadus*).
Star, Harvest-fish (*Peprilus Alepidotus*).
Butter-fish (*Poronotus Tricanthus*).
Calico Bass; Speckled Perch (*Pomoxis Sparoides*).
Flier (*Centrarcus Macropterus*).
Rock Bass (*Ambloplites Rupestris*).
Goggle-eyes; Warmouth (*Chaenobryttus Gulosus*).
Long-eared Sun-fish; Red-belly; Robin (*Lepomis Auritus*).
Blud Joe; Blue-gills; Blue Sun-fish (*Lepomis Incisor*).
Holbrook's Sun-fish (*Lepomis Holbrooki*).

Sand Perch; Pumpkin-seed (*Lepomis Gibbrosus*).
Black Bass; small mouthed (*Micropterus Dolomien*).
Black Bass, large mouthed (*Micropterus Salmoides*).
Pike Perch; Wall-eyed Pike (*Stizostedion Vitreum*).
Yellow Perch; Red-fin (*Perca Flavescens*).
Striped Bass; Rock-fish (*Roccus Lineatus*).
White Perch (*Marone Americana*).
Black-fish; Sea Bass (*Centropristes Striatus*).
Pig-fish; Hog-fish (*Orthopristis Chrysopterus*).
Snapper; Grunt (*Hæmulon Plumieri*).
Scup; Pin-fish (*Stenotomus Chrysops*).
Sailsois choice; Robin (*Lagodon Rhomboides*).
Sheepshead (*Archosargus Probatocephalus*).
Squeteague; Weak-fish; Sea Trout (*Cynoscion Regalis*).
Spotted Squeteague; spotted Weak-fish (*Cynoscion Nebulosus*).
Yellow Tail; Sand Perch; Perch (*Bairdiella Chrysura.*)
Spot (*Leiostomus Xanthurus*).
Croaker (*Micropogon Undulatus*).
Red Drum; Red-fish (*Sciaenops Ocellatus*).
King-fish; Sea Mullet; Carolina Whiting (*Menticirrhus Americanus*).
Sea Mullet; King-fish (*Menticirrhus Saxatilis*).
Surf Whiting (*Menticirrhus Littoralis*).
Black Drum (*Pogonias Cromis*).
Oyster-fish; Tautog (*Tautoga Onitis*).
Porgee, Spade-fish (*Chaetodipterus Faber*).
Cod (*Gadus Callarias*).
Flounder; Summer Flounder; Plaice (*Paralichthys Dentatus*).
Flounder, Southern, (*Paralichthys Lethostigmus*).
Flounder (*Paralichthys Albiguttus*).

All the fishes mentioned in this list are found to a greater or less extent in the markets, but only a few of them are of any large economic value to the State. Of the migratory fishes, the most conspicuous and the ones of most value are

the shad, alewives, hickory shad, striped bass, white perch, eel and sturgeon. Of the salt water fishes would be included the mullets, squeteagues, Spanish mackerel, croaker, spot and menhaden. The principal fresh water fish is the large-mouthed black bass. The spotted squeteague, pig fish, hickory shad and black bass are taken in larger quantities in North Carolina than in any other State.

On account, however, of over-fishing and non-enforcement of present laws relating to the fisheries, the industries are deteriorating and in some instances quite rapidly. Unless the State will provide prompt and adequate protection to the shad, alewives, striped bass and other species which are beginning to show a decrease in abundance, they will soon share the same fate as the sturgeon.

There is no reason why the fisheries of North Carolina should not be maintained for an indefinite period and even be very greatly improved; and to this end the session of the Legislature of 1907 created a Fsh Commission, but with very limited powers. It is to be hoped that at the session of 1909 the powers of the Fish Commission will be increased so that it will be in a position to prevent the causes of decline in these industries and be able to utilize all resources for building up and increasing the abundance of fish.

The Geological and Economic Survey, in coöperation with the United States Bureau of Fisheries, has carried on certain lines of work in regard to the protection and reproduction of the fishes of North Carolina, conducted through the Biological Laboratory at Beaufort, the hatchery at Edenton and the temporary hatching stations near Weldon. A number of fish have been introduced into the waters of North Carolina, some of which have become widely distributed and firmly established, such as the rainbow or California trout and the carp.

Large numbers of native fishes from outside hatcheries have been planted in the State, among these being the brook trout, large-mouthed and small-mouthed black basses, various sun-fishes, and several kinds of cat fishes.

REVIEWS

Van Nostrand's Chemical Annual, 1907. First Year of Issue. Edited by John C. Olsen, A. M., Ph. D. New York, D. Van Nostrand Co. x - 496 pp. The "Chemiker Kalendar" has long been a most useful publication but American chemists have desired a similar publication in English. In the new Annual Professor Olsen has improved upon the German model and produced an extremely satisfactory reference work. It consists exclusively of tables of physical and chemical data and lists of pnblications. The physical constants of inorganic and organic compounds are given in two tables, comprising nearly one half of the book. It is a pleasure to find frequently definite values for solubilities. The "Review of Chemical Literature" consists of a classified list of the more important articles published in the Journals and also a classified list of books, the time covered being from Jan. 1, 1905 to June 1, 1906. It is cause for congratulation that Professor Olsen undertook the editorship of a book which is so indespensible to the chemist. The execution of the mechanical part is excellent. A. S. W.

Solubilities of Inorganic and Organic Substances. A hand-book of the most reliable quantitative solubility determinations. Recalculated and complied by Atherton Seidell. 8vo X - 367 pp. D. Van Nostrand Company. New York, 1907. The only dictionary of chemical solubilities has been Comey's which was published in 1894. Although it is a book of great value there are several defects which detract from its usefulness. It contains no organic substances but we find instead a great variety of rare inorganic double salts. Too many unreliable determinations are incorporated and the arrangement is not consistent throughout so that it is fre-

quently troublesome to locate a compound. Seidell has introduced a large number of important organic substances, the selection of inorganic compounds is more satisfactory, the arrangement is logical throughout, and the determinations are more reliable. Greater reliability was arrived at with much labor by recalculating the various determinations to a common basis and drawing curves through the points plotted. Selections were then made after comparing the curves and studying the methods of determination. An index adds to the value of the book. Every chemist should have access to this thoroughly satisfactory dictionary, in fact it should be in every working scientific library. A. S. W.